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ABSTRACT

In response to a 1982 request by the U.S. Department of the Army, the National Research Council's Board on Army Science and Technology established the Committee on Army Manpower to investigate the professional environments and use of civilian and military scientists/engineers in Army laboratories. The committee's primary objective was to identify steps the Army could take to better ensure that its laboratory personnel contribute most effectively to accomplishing the laboratories' missions. Provided in this document are the committee findings, conclusions, and recommendations which are based on extensive laboratory site visits/interviews, on discussions with experts in the field of human factors research, on the findings/recommendations of prior studies of research and development (R&D) institutions, and on the committee members' experience in managing such institutions. Observations, conclusions, and recommendations are reported in separate sections for: leadership; personnel policies/procedures; policies concerning professional growth and recognition; resources; and R&D programs. The framework for analyzing each of these areas and future trends (considering demography, labor supply/demand and Army plans) are also reported. Supporting documentation (including laboratory staff consulted, questions of the committee when meeting with laboratory personnel, list of principal documents reviewed by the committee, and others) are provided in seven appendixes. (JN)

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The Professional Environment in Army Laboratories and its Effect on Scientific and Engineering Performance

A Report Prepared by the
Committee on Army Manpower
Board on Army Science and Technology
Commission on Engineering and Technical Systems
National Research Council

NATIONAL ACADEMY PRESS
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their specific competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Commission on Engineering and Technical Systems
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

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* * * * *

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JERRIER A. HADDAD (Member, Ex Officio), Consultant, Briarcliff Manor, New York; Member, Board on Army Science and Technology

WALTER B. LABERGE (Member, Ex Officio), Vice President, Planning and Technology, Lockheed Missiles and Space, Sunnyvale, California; Member, Board on Army Science and Technology

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PREFACE

This study was initiated by the Deputy Chief of Staff for Research, Development and Acquisition of the U.S. Department of the Army as part of the greater Army effort to ensure that its laboratories perform the roles they must, both today and in the future. The Committee on Army Manpower was appointed by the Commission on Engineering and Technical Systems of the National Research Council to identify steps that the Army could take to enhance the professional environments of its laboratories to better achieve mission requirements through high performance.

A basic assumption of the committee is that quality personnel are needed to accomplish laboratory missions, and that salutary professional environments are needed to attract and retain quality personnel. As a result, the primary emphasis of the committee's study and of its report is on characterizing the professional environments in research and development laboratories--the committee examined at first hand the professional environments of 11 Army laboratories and 4 non-Army government and industrial laboratories--and on determining the effect of the professional environments on scientific and engineering performance. Given the importance of this effort, together with constraints on time, the committee found it impossible to give more than cursory treatment to one of its originally assigned tasks--that of, suggesting a better system for evaluating the performance of the Army's scientific, engineering, and technical personnel (item 7 of Appendix A). The committee believes that this topic should be given the attention it deserves in another study.

The committee also realizes the importance to the Army of work performed by civilian scientists,

engineers, and technicians working in operations and headquarters units outside Army laboratories. An assessment of the professional environments of this cadre of workers is also suggested by the committee.

The committee acknowledges the invaluable advice and encouragement of James E. Spates of the Army's Office of Research, and Jerrier A. Haddad, Alfred Gessow, and Walter B. LaBerge of the Board on Army Science and Technology (BAST) of the National Research Council. The committee is also indebted to Dennis F. Miller, Executive Director of BAST, for his comprehensive and stimulating guidance of its activities, and to Patricia L. Poulton, who served as the committee's staff officer, for her tireless and intelligent assistance in all aspects of the committee's endeavors. The committee appreciates the special assistance of Helen D. Johnson, Julia W. Torrence, and Beulah S. Bresler of the administrative staff, as well as Ann Covalt's fine editorial work. Finally, the committee expresses its gratitude to those personnel with whom it dealt at the Naval Research Laboratory, at the Oak Ridge National Laboratory, at the International Business Machines Corporation laboratories in Owego and Endicott, New York, and at all levels of the Army for their courteous and unstinting cooperation, warm hospitality, and informative responses to many requests. The committee sincerely hopes that its report will help the Army respond most effectively to the challenges it faces in the years ahead.

John W. Landis, Chairman
Committee on Army Manpower

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SUMMARY

APPROACH

In response to a 1982 request by the U.S. Department of the Army, the National Research Council's Board on Army Science and Technology established the Committee on Army Manpower to investigate the professional environments and use of civilian and military scientists and engineers in Army laboratories. The committee's primary objective was to identify steps the Army could take to better ensure that its laboratory personnel contribute most effectively to accomplishing the laboratories' missions. Fundamental to the committee's work is the basic assumption that quality personnel are needed to achieve mission objectives and that salutary professional environments are needed to attract and retain quality personnel.

The committee examined at first hand the professional environments of 11 of the 34 Army laboratories, representing a wide range of missions. The committee also visited 4 non-Army government and industrial laboratories that have reputations for excellence and productivity. During its 15 laboratory visits, the committee received full cooperation and candid opinions from laboratory professionals at all levels, ranging from those at the bench through their mid-level supervisors and laboratory directors. This information was supplemented by briefings in Washington, D.C. In sum, the committee based its findings on extensive laboratory site visits and interviews, on discussions with experts in the field of human factors research, on the findings and recommendations of prior studies of research and development institutions, and on the committee members' experience in managing such institutions.

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The committee concluded that Army management at all levels, if it is to establish laboratory environments in which scientists and engineers can work productively, must handle effectively five key areas of laboratory operations: leadership, personnel policies and procedures, opportunities for professional growth and recognition, laboratory resources, and the research and development program itself. The committee observed many strengths in the Army laboratories visited, which compared well with their non-Army counterparts. However, in each of the five areas of Army laboratory operations, the committee found disturbing trends--trends that, if not reversed, may seriously impair the quality of the Army's future combat and combat-support systems. For example, the trend toward contracting out much of the laboratories' basic research and exploratory development work is jeopardizing the Army's in-house capability to develop and apply new technology to changing operational needs. Also very disturbing is the trend toward micromanagement of laboratory resources by each of the three or more layers of management at Army headquarters in the Washington, D.C., area and at major subordinate commands.

To help counteract these trends, the committee identified more than 40 actions that could be taken to strengthen the Army laboratory community so that it can better ensure that its laboratories attract and retain the scientific and engineering talent needed to accomplish their missions. Many of the committee's suggested actions can be taken by Army laboratory directors through the authority they now have. Others would require that changes be made at various Army command levels or by authorities outside the Army, such as the Secretary of Defense, the Office of Personnel Management, the Office of Management and Budget, and the Congress. The following paragraphs highlight those actions that the committee believes are of the highest priority. The following report elaborates on these principal recommendations and presents others that the committee believes are almost as important.

PRINCIPAL RECOMMENDATIONS

Leadership

- To better ensure technically competent laboratory leadership, the Army should institute the practice of assigning as directors of Army laboratories only highly qualified senior civilians or military scientists and engineers, that is, individuals with graduate education in science or engineering and with long-term experience in conducting and managing research and development. Such personnel should be expected to serve in this capacity for a minimum of 5 years.
- The Army should actively promote and support its long-standing program of graduate education and career development for military personnel in the field of research and development, taking into account operational military needs. It should encourage those with a bachelor's degree in science or engineering or with experience in conducting and managing research and development to enter the program early in their military career and then ensure that they are acquainted with military applications of science and technology. These individuals will then be better prepared to manage and conduct research and development.
- Army headquarters should provide its laboratory directors, as well as its scientists and engineers, with consistent objectives that are both achievable and specific. The Army should then delegate the necessary responsibility to allow the laboratories to perform the creative and innovative research and development required to meet these goals.

Personnel Policies and Procedures

- The federal pay system should be amended by the Congress to permit higher beginning salaries for new graduates possessing unique and needed skills so that these salaries are competitive.
- Job candidates should be brought to Army laboratories to see the work place and meet potential colleagues. The Army should reimburse candidates for the expenses incurred by such interviews.
- The Army should modify its hiring procedures to allow a job offer to be made shortly after an interview

when necessary in the view of the responsible scientific staff officers.

- o Army laboratories should maintain and emphasize the "dual ladder" promotion system in advancing scientists and engineers.
- o To the full limit of its authority, the Army should implement the federal merit pay system in its laboratories in order to provide greater rewards to more personnel with less administrative effort and paperwork. If this is not possible, the Army should recommend to the administration and to the Congress appropriate legislative changes in the federal merit pay system.

Opportunities for Professional Growth and Recognition

- o The Army and its laboratory managers should continue to encourage graduate training for its professionals, publication of their significant research and development results, their participation in technical conferences, their communication with peers at other institutions, and their job mobility within and among laboratories.
- o Laboratory directors should emphasize immediate cash awards that senior and middle managers can give to their personnel to recognize merit in work when the managers judge it appropriate.

Laboratory Resources

- o To maintain an adequate mix of technical skills and experience, the Army should press for changes in those policies affecting personnel actions and laboratory manpower allocations so that research and development teams can be properly balanced. The experience and expertise of team members will then match job requirements. However, before this can be accomplished, Congress will need to amend Title V, United States Code, Chapters 55 and 56 to provide a mechanism for incorporating personnel policy changes--such as those related to job classifications and reduction-in-force (RIF) procedures--across the board. Actions to modify the laboratories' manpower allocations could be achieved within the current Army structure. Changes in these two

areas would provide the Army and its laboratory directors more flexibility in hiring and moving personnel to match the funded workload.

- A certain fraction--5 to 10 percent--of Army laboratory operating costs should be allocated to acquire research and development equipment costing approximately $3,000 or more. This fund should be programmed and budgeted by laboratory directors, and should not compete with that for general equipment such as cars and trucks, machine tools, and cranes. Funding mechanisms currently available to the laboratory director (i.e., project monies or funds provided for the In-House Laboratory Independent Research Program) are considered insufficient for equipment purchases of this magnitude.
- The Army should update its substandard laboratory facilities. Laboratories with substandard plant and equipment should be supported by Army headquarters in Army budget requests to the Congress for the funds necessary to improve their facilities so that their professionals can successfully meet mission requirements.

The Research and Development Program

- To maintain required technical expertise and environments that produce high-quality research and development, Army laboratories should operate under the general rule that a significant percentage--for example, more than half--of their basic research and exploratory development should be performed in-house.
- The Army should restrict project managers' staffs to primarily administrative roles, which would depend on the laboratories for technical support.

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INTRODUCTION

BACKGROUND AND STATEMENT OF TASK

In the decade ahead, the U.S. Department of the Army is faced with the formidable task of acquiring and retaining the technological competence it needs to ensure strong national security; the technological competence is needed both in-house and in the industrial and academic base that supports defense preparedness. Crucial in meeting this challenge is an effective Army laboratory community. This group must work with its colleagues in industry, universities, and other U.S. Department of Defense laboratories to develop and maintain the technological skills and insight needed to achieve the outstanding science and technology that the Army's mission requires, and to apply the results to the successful development and acquisition of military systems.

The 34 Army laboratories constitute the nucleus of this research and development community. Table 1 lists these institutions and their established command elements: the Commanding General of the U.S. Army Materiel Development and Readiness Command (DARCOM); the Chief of Engineers; the Surgeon General; and the Deputy Chief of Staff for Personnel. While these laboratories vary in size, location, distribution and type of work, composition of technical staff, command structure, and mission, they all strive to fulfill their individual research and development roles. For this they require a strong scientific and engineering work force and adequate resources.

To help ensure that these needs are met, the Office of the Deputy Chief of Staff for Research, Development and Acquisition of the U.S. Department of the Army

TABLE 1 Army Research and Development Laboratories and Their Command Elements

Army Laboratories	Command Chain	
	Intermediate	Command
Aeromedical Research Laboratory	Medical R&D Command	The Surgeon General
Atmospheric Sciences Laboratory	Electronics R&D Command	DARCOM
Aviation Research and Technology Laboratory	Aviation R&D Command	DARCOM
Ballistic Research Laboratory	Armament R&D Command	DARCOM
Biomedical Laboratory	Medical R&D Command	The Surgeon General
Chemical Systems Laboratory	Armament R&D Command	DARCOM
Cold Regions Research and Engineering Laboratory	--	Chief of Engineers
Combat Surveillance and Target Acquisition Labs	Electronics R&D Command	DARCOM
Communications R&D Command	--	DARCOM
Construction Engineering Research Laboratory	--	Chief of Engineers
Electronic Warfare Laboratory	Electronics R&D Command	DARCOM
Electronics Technology & Devices Laboratory	Electronics R&D Command	DARCOM
Engineer Topographic Laboratories	--	Chief of Engineers
Engineer Waterways Experiment Station	--	Chief of Engineers
Fire Control and Small Caliber Weapons Systems Lab	Armament R&D Command	DARCOM
Harry Diamond Laboratories	Electronics R&D Command	DARCOM
Human Engineering Laboratory	--	DARCOM
Institute of Dental Research	Medical R&D Command	The Surgeon General
Institute of Surgical Research	Medical R&D Command	The Surgeon General
Large Caliber Weapons Systems Laboratory	Armament R&D Command	DARCOM
Letterman Army Institute of Research	Medical R&D Command	The Surgeon General
Materials and Mechanics Research Center	--	DARCOM
Medical Bioengineering R&D Laboratory	Medical R&D Command	The Surgeon General
Medical R&D Command	--	The Surgeon General
Medical Research Institute of Infectious Diseases	Medical R&D Command	The Surgeon General
Missile Command	--	DARCOM
Mobility Equipment R&D Command	--	DARCOM
Natick R&D Labs	--	DARCOM
Night Vision and Electro-Optics Laboratory	Electronics R&D Command	DARCOM
Research Institute for Behavioral and Social Sciences	--	Deputy Chief of Staff for Personnel
Research Institute of Environmental Medicine	Medical R&D Command	The Surgeon General
Signals Warfare Laboratory	Electronics R&D Command	DARCOM
Tank-Automotive Command	--	DARCOM
Walter Reed Army Institute of Research	Medical R&D Command	The Surgeon General

requested that the National Research Council's Commission on Engineering and Technical Systems examine the professional environments of Army laboratories with regard to attracting, retaining, and motivating effective laboratory personnel. (See Appendix A, Statement of Task.) Through its Board on Army Science and Technology, the commission established the Committee on Army Manpower (Appendix B) to conduct the study. The main goal of the study was to identify steps that the Army could take to better ensure that its laboratories attract and retain the scientific and engineering talent needed to accomplish their missions. The committee accepted the basic assumption that high-quality personnel are required to produce high-quality results, and that acquiring and retaining such personnel in turn requires a salutary professional environment.

STUDY METHODOLOGY

The study examined at first hand the professional environments in selected Army and non-Army research and development laboratories. The 4 non-Army laboratories visited have reputations for excellence and productivity; they are the Naval Research Laboratory, Washington, D.C.; International Business Machines Corporation laboratories at Owego and Endicott, New York; and the Oak Ridge National Laboratory, Oak Ridge, Tennessee. Although many other non-Army laboratories qualify for excellence and productivity and might also have been visited, this sample of four laboratories was deemed to provide an adequate composite for comparison. The work environments of these institutions were then compared with those of the 11 Army laboratories (listed in Appendix C) visited by the committee.

Each site visit lasted approximately 1 day, and usually included a briefing by the laboratory director on the technical mission of the institution, its research and development objectives, and its connections with the government or other parent organizations. Briefings were also given specifically on personnel matters, for example, on employees' age distribution; attrition rates; support for advanced education; mobility, both lateral and vertical; benefit plans; and salaries. In these discussions, attention was directed to recruiting and hiring practices, maintaining the motivation of scientists and engineers, promotions,

performance appraisals, and the laboratory's methods of communication.

These briefings were followed by committee discussions with a group of six or seven members of the laboratory staff, both supervisors and bench workers. The discussions tended to substantiate the material provided by the briefings, with an occasional disagreement surfacing between the laboratory staff members and the formal briefing statements. In no case did the committee feel that the areas of disagreement were significant.

The group discussions were followed by laboratory visits. For this purpose, the committee broke up into small groups and visited individual laboratories to gain some knowledge of the equipment, the degree of available space, the availability of computers, the housekeeping, and the kind and degree of activity in the laboratory. Brief conversations were also held with staff members about their work and about their perceptions of the environment in which they work. (Appendixes D through F provide a sample of the request letter sent to laboratory directors, a list of laboratory staff consulted by the committee, and the questions asked by the committee when meeting with laboratory scientists, engineers, and technicians.) The information obtained during site visits was supplemented by further briefings in Washington, D.C., and by a review of related literature.

Appendix G provides a list of principal documents reviewed by the committee. Two studies listed--the Report of the Army Science Board 1982 Summer Study Panel on Science and Engineering Personnel (Army Science Board, 1982), and the U.S. Department of Defense Laboratory Management Task Force's (1982) Study of Scientists and Engineers in DOD Laboratories---provide laboratory statistical information (for example, size and composition of technical staff, ratio of military personnel to civilian) that may prove valuable to readers of this report.

2

FRAMEWORK OF THE ANALYSIS

Every laboratory strives to produce high-quality research and development. It can succeed only if it maintains standards of excellence in a number of important areas. These include hiring and retaining high-quality personnel, undertaking programs and projects based on strategic planning, encouraging creativity in research and development, providing facilities equal to the laboratory's task, maintaining communication with the broader scientific community, systematically reviewing the laboratory's program, and exercising quality control over the laboratory's published results. Establishing a professional environment that fosters and sustains high standards is the responsibility of management at the laboratory and at higher levels, and depends on the laboratory managment's quality, programs, and policies.

The Committee on Army Manpower has organized its observations and recommendations according to five different, though sometimes closely related, areas of laboratory management:

- Leadership
- Personnel policies and procedures
- Opportunities for professional growth and recognition
- Laboratory resources
- Research and development programs

These categories were chosen for analysis because they were frequently singled out during the committee's extensive laboratory site visits, interviews, and discussions with experts in human factors research, as

well as in the findings and recommendations of prior studies of research and development laboratories, and they also corresponded with the committee members' experience in managing research and development organizations. Probably no one set of categories will be universally accepted, but the main point is that they encompass the range of important management concerns. The committee believes that these categories do so, and thus constitute a satisfactory framework for analysis. The following paragraphs briefly explain the significance of each category.

LEADERSHIP

The leadership of the laboratory director and of those at the corporate or command headquarters levels above the director plays a central role in determining the quality, performance, occupational stability, and satisfaction of all laboratory personnel. Within the boundaries imposed by higher levels of management, the laboratory director's office can choose among policies that enhance or impede all laboratory operations, as well as the systems and practices to implement them--from personnel procedures to the methods of contracting research and development tasks. The director's office is responsible for laboratory program planning and review, and oversees the acquisition and allocation of laboratory resources within budgetary constraints. It sets the pattern of communication within the laboratory and between itself and the organizations with which it interacts and to which it reports. It interprets and implements the policies and practices set by its parent organization for recruiting and hiring personnel and for recognizing personnel achievement. The quality and stability of its own leadership over the years is a primary factor in determining the laboratory's reputation in its field. It is also a primary factor in maintaining talented and productive scientific and engineering personnel.

PERSONNEL POLICIES AND PROCEDURES

The personnel policies and procedures of a laboratory and its parent organization are important in attracting and retaining good scientists and engineers and in

providing them rewarding careers. Undue bureaucratic complications and delays in recruiting, for example, can put a laboratory at a serious disadvantage in competing for talented science and engineering graduates. Uncompetitive salaries and benefits, of course, also impede recruiting and retaining good personnel. Laboratories must provide opportunities for advancement and increased responsibilities. Similarily, their promotion and termination procedures and practices must be regarded as straightforward and fair.

OPPORTUNITIES FOR PROFESSIONAL GROWTH AND RECOGNITION

Opportunities for education and training and for communicating with peers through publications, meetings, and participation in the activities of professional societies are all important means of motivating laboratory scientists and engineers. Opportunities for specialized training also help ensure that their professional skills stay current. Incentive and award programs are likewise important. All these measures influence laboratory research and development. They are most effective when offered impartially and publicly.

RESOURCES

A laboratory's professional environment is greatly affected by the availability of resources. Laboratory scientists and engineers cannot be fully productive, no matter how motivated or talented they are, without appropriate support. Shops, libraries, laboratory supplies and equipment, computer facilities, and other resources must be sufficient, well situated, and well maintained. The services of competent technicians, computer programmers, and administrative personnel must also be available without undue delays. The laboratory's funding must be adequate to achieve its program goals and must be provided on a schedule so that the laboratory's work is not interrupted. The mix and size of a facility's technical divisions also significantly affect its research and development.

RESEARCH AND DEVELOPMENT PROGRAMS

Program content, stability, and impact strongly influence the quality of laboratory research and

development. Laboratory scientists and engineers are highly motivated by challenging and important work. If they feel that their work is irrelevant to their clients or that their clients fail to take full advantage of the laboratory's results, they may seek other employment. This applies particularly to more talented and highly motivated individuals whom the Army can least afford to lose. Work stability is also essential to productive research and development. Finally, the proportion of research and development that is conducted in-house greatly influences the types and quality of professionals a laboratory can attract and retain.

3

LEADERSHIP

OBSERVATIONS

Non-Army Laboratories

Quality and Stability of Leadership

At the Naval Research Laboratory (NRL), the Oak Ridge National Laboratory (ORNL), and International Business Machines Corporation (IBM) laboratories (the Owego Engineering Laboratory and the Glendale/Endicott Product Laboratory) the leadership is highly educated and stable. Senior managers at these institutions can expect to remain in their jobs for a considerable length of time; if they perform as expected, they are usually not relieved of responsibility or transferred for the sake of change.

Scientists and engineers managing NRL's program, for example, are highly educated, experienced managers of research and development. At ORNL, members of the director's management team are researchers and managers highly respected both within and outside their institution. Similarly, IBM senior managers, whose average length of service is 14 years, are considered extremely able and productive professionals.

Functions of Leadership

Program planning and review and the allocation of resources are fundamental functions of management. A manager's ability to develop challenging programs and assignments that are consistent with laboratory goals greatly influences the professional environment. Thus,

the leadership at NRL, ORNL, and IBM expends much effort in setting performance standards for conducting research and development and in monitoring and measuring the quality and effectiveness of results. Most important, when productivity at these laboratories declines, reasons for the decline are sought and corrective action is applied. Sometimes the cause is internal and sometimes it is found in the parent organizations.

While the management at all these institutions sets research and development objectives, it leaves the question of how to achieve them to the scientific and engineering staff. This provides the staff with necessary direction and at the same time with the freedom of action essential for productive and innovative work. Managers at the four non-Army institutions discussed here try to shield their research and development staffs from the effects of fluctuating funding and from bureaucratic regulations. Nevertheless, NRL and ORNL both have suffered more paperwork, much to the annoyance of the staff.

Another principal function of the managers in these laboratories is to ensure that employees have access to management and information through numerous channels. The IBM laboratories, through their written communications, are perhaps the most effective of the group. Each employee at the Owego laboratory regularly receives eight IBM publications. The four laboratories together employ a variety of techniques to encourage communication: "open door" policies, hot lines, in-house publications, staff meetings, recorded messages available through inside telephone lines, and conversations between individual senior managers and members of the research and development staff.

While the methods employed differ from one laboratory to another, all four emphasize effective and frequent communication between management and the research and development staff. Ensuring such communication is figured in evaluating management at all levels. At IBM, first-level managers are expected to spend 30 percent of their time in "people managing." This is considerably higher than the corresponding figures for NRL and ORNL and may well account for the exceptionally high morale found at the two IBM laboratories.

Another function performed by the leadership at ORNL is that of obtaining sound external advice by means of advisory committees. These advisory committees also play an important role in the communication process. They fulfill four separate requirements: (1) reviewing

the technical work of a research unit (composed of 75 to 200 professionals) and reporting their findings to the laboratory director, (2) serving as an audience for those members of the research and development staff who present their results, (3) functioning as a link to the greater scientific and engineering community, and (4) communicating other problems and ideas of the research and development staff to senior management. Thus, these advisory committees accomplish several kinds of communication as well as performing technical reviews.

Army Laboratories

Quality and Stability of Leadership

Technically qualified military officers and civilians serve as the senior managers at a number of Army laboratories. At the Walter Reed Army Institute of Research (WRAIR) the director's immediate staff, which is primarily military, is highly educated and has been associated with the institute for a long time. All professional staff at WRAIR must have at least a master's degree, and most have either an M.D. or a Ph.D. WRAIR's current senior management has been associated with the institute for more than 15 years. The division directors, as well as the director and deputy director of the institute, are military physicians and scientists who contribute knowledge of the contemporary Army along with their scientific expertise. Directly under these division directors are department chiefs, mostly civilians, who add to the stability of the institute's research and development efforts through their longer periods of service.

Most nonmedical Army laboratory military directors, however, are much less experienced than those of WRAIR in managing research and development--directors of 2 of the 11 laboratories visited are serving in their first research and development assignments--and lack the academic credentials necessary to manage highly technical work effectively. This situation is unfair to the career development of the military officer, usually a colonel still advancing in his career; but more importantly, it is unfair to the laboratory, which is denied a highly qualified director.

Unqualified military leadership also places an undue burden on civilian deputy directors. The problem is

compounded when middle managers are not aware of recent developments in their fields, are unable to recognize and encourage quality work, and cannot terminate work of poor quality or questionable value for Army needs. It is further compounded by the normal rapid change of military personnel and the frequent reorganization of some Army laboratories every 2 or 3 years.

Also of critical importance are the technical qualifications and experience of the top-level civilian managers, who must complement military officers and provide continuity during transition periods. Many of the civilian managers observed by the committee were considered quite effective in this regard. However, the level of authority and general responsibilities of civilian laboratory managers are not consistent from laboratory to laboratory. Therefore, the influence of some is less than optimal.

Functions of Leadership

Because discipline is integral to military organizations, the Army's program planning and review and allocation of laboratory resources are generally aimed at order and uniformity rather than at flexibility. Although this tendency helps some laboratories to meet their mission requirements, it is evident that too much control adversely affects the motivation, independence, and initiative of researchers at the majority of these Army research and development institutions.

Communication is an important management tool in the Army laboratory community. Its successive layers of management within the laboratories themselves and at higher headquarters, however, tend to require too much reporting, both oral and written. A large percentage of professionals' time at all levels of the laboratory is consumed by administrative tasks and meetings. Some laboratory directors have realized the importance of reducing this burden on their scientists and engineers and have hired personnel to respond to administrative queries and Army regulations. Such staff help shield the researchers, but still depend on them for the data to fulfill reporting requirements. These staff members also contribute to heavy laboratory overhead and require an inordinate number of scarce high-grade positions.

Another important function of leadership is to avoid the duplication of management and support arrangements

that would result in the inefficient use of scarce resources and high-grade positions. But duplication of this sort is found when a number of independent laboratories are located at the same installation (e.g., at Picatinny Arsenal, Fort Monmouth, Fort Belvoir, and Natick).

CONCLUSIONS

The quality and policies of senior management influence all aspects of a laboratory and greatly influence its research and development. While management styles can vary, it is clear from the committee's observations and experience that the managers of effective laboratories are highly qualified technical personnel, have earned the respect and support of their staff members, have long-term experience in managing research and development at a laboratory or similar institution, and are concerned with the quality of their product as well as with the management of their staff. They are open with their staffs and encourage their subordinates to be equally so. External advisory committees can be helpful in evaluating research and development and in providing communication within an organization as well as links to appropriate outside communities. The effective managers encourage independence and know how to make their laboratories respond to the needs of parent organizations without losing this independence. Finally, the active support of management in avoiding bureaucratic interference and inefficiency has a positive effect on laboratory morale.

RECOMMENDATIONS

o To better ensure technically competent laboratory leadership, the Army should institute the practice of assigning as directors of Army laboratories only highly qualified senior civilians or military scientists and engineers, that is, individuals with graduate education in science or engineering and with long-term experience in conducting and managing research and development. Such personnel should be expected to serve in this capacity for a minimum of 5 years.

o The Army should actively promote and support its long-standing program of graduate education and career development for military personnel in the field of

research and development, taking into account operational military needs. It should encourage those with a bachelor's degree in science or engineering or with experience in conducting and managing research and development to enter the program early in their military career, and then ensure that they are acquainted with military applications of science and technology. These individuals will then be better prepared to manage and conduct research and development.

o Army headquarters should provide its laboratory directors, as well as its scientists and engineers, with consistent objectives that are both achievable and specific. The Army should then delegate the necessary responsibility to allow the laboratories to perform the creative and innovative research and development required to meet these goals.

o The parent organization should appoint external advisory committees to review each Army laboratory annually and to provide them independent technical advice. The membership of these advisory committees should include both Army and non-Army personnel.

o To decrease administrative reporting, the Army should reduce the number of management levels that can place reporting and other requirements on laboratories, should eliminate duplication of reports, and should consolidate those reports found essential. It should also reduce the number of approvals necessary for simple tasks and decisions.

o Where specialty areas do not preclude it, laboratories located at the same installation (e.g., at Picatinny Arsenal, Fort Monmouth, and Fort Belvoir) should be consolidated to reduce redundant and costly management.

4

PERSONNEL POLICIES AND PROCEDURES

OBSERVATIONS

Non-Army Laboratories

Compensation

The laboratories of International Business Machines Corporation (IBM) at Owego and Glendale/Endicott and the Oak Ridge National Laboratory (ORNL) all enjoy an inherent advantage in operating: they are not bound by federal civil service regulations, e.g., those that restrict the number of high-level positions established and those that restrict salaries within grades. The managers of these laboratories have more latitude in interpreting personnel procedures and policies. The policy of both organizations is to "pay for performance," not for seniority, and to maintain competitive pay scales. At ORNL, the beginning salary of a Ph.D. chemical engineer is about $31,000, and the beginning salary of a B.S. chemical engineer is about $25,000. Beginning federal salaries are cited later in this chapter in the discussion of compensation in Army laboratories; they are much lower.

Recruitment

The management of the two IBM laboratories, ORNL, and the Naval Research Laboratory (NRL) employs several effective methods of recruitment. All four laboratories regularly send technical staff to recruit at a number of universities. Two levels of management from IBM's Owego

Engineering Laboratory, for example, travel to approximately a dozen universities each year to interview potential candidates. All the laboratories also try to maintain some year-to-year continuity in their recruiting teams. Another effective management approach is to bring promising individuals to the laboratory to show them the place where they may work, to introduce them to prospective colleagues and supervisors, and to provide them some hospitality. It is standard policy for these laboratories to pay for such visits. This method of recruitment is considered especially important for laboratories located outside major metropolitan areas, such as IBM's Owego and Endicott facilities in New York state.

The hiring practices of these facilities also contribute to attracting outstanding engineering and science students from the nation's most prestigious colleges and universities. ORNL's success in this regard is evidenced by the profile of 325 Ph.D.'s who accepted employment at the laboratory between 1977 and 1982. The laboratory's average new employee during this period was 32.3 years old, had a grade point average of 3.35 as an undergraduate, and a grade point average of 3.73 as a doctoral candidate. The universities at which these employees studied include those in the University of California system, Cornell, Duke, Georgia Institute of Technology, Harvard, Massachusetts Institute of Technology, Princeton, Purdue, Stanford, and Yale.

Managers at all four laboratories make every effort to be as prompt as possible in offering jobs. IBM and ORNL can make an offer to a candidate during a visit, although at ORNL the offer more commonly follows the interview by 2 to 4 weeks. NRL hires about 4 weeks after an interview when a security clearance is not required and about 3 months afterward when it is required. At NRL and IBM the decision to hire is made by the immediate supervisor and needs only one additional level of approval. At ORNL, three levels of approval are required, including the approval of the laboratory director.

Promotion

All four laboratories have a "dual ladder" system of promotion so that employees can advance in either the area of research and development or that of technical management. Managers and working scientists and

engineers at these facilities indicate that employees can move between these professional areas and that the system works well. Professionals can be paid according to their performance instead of according to their choice of professional area.

Although IBM and ORNL do not have a problem with employees' being stalled at one grade level as in government laboratories (see the section on Army promotions below), both laboratories of course have a distribution of positions that thins out markedly at the top.

In general, management experience has shown that if higher grades are restricted to management personnel, the quality of research and development will be poorer and the staff will be dissatisfied and excessively preoccupied with grade levels and politics. As a result, managers at all these non-Army laboratories try to distribute high-level positions equally between the technical and managerial staffs.

Termination

While managers at these institutions try to improve the productivity of marginal performers, they believe that such employees should be terminated if, after some period of time, little progress is made. ORNL tries not to reappoint staff who are unsuccessful after 2 years. Once staff members have been at the laboratory for more than 5 years and have consistently been rated satisfactory, it is much less likely that their employment will be terminated.

Personnel Administration

Another factor contributing to the quality of personnel and the timeliness of personnel action at these laboratories is that personnel managers report to and have their performance evaluated by the laboratory director and are identified as members of his team. IBM laboratory managers, for example, report directly to the laboratory director. At the same time, IBM's personnel staff at corporate headquarters monitors their overall performance. This organizational arrangement allows each manager to be responsive to a given laboratory's personnel needs while also developing and maintaining procedures consistent with overall IBM policy.

Army Laboratories

Compensation

Managers at Army laboratories are limited by Civil Service Act provisions in their ability to offer competitive beginning salaries to scientists and engineers. Under the federal salary schedule in effect as of October 1982, professionals without graduate training must enter the Army either at the GS-5 level ($13,369) or at Step 1 of the GS-7 level ($16,559). An offer at the GS-9 level ($20,256) can be made to those with a master's degree, and at the GS-12 level ($29,374) to those with a doctorate.

The federal Office of Personnel Management has determined that there are certain skill shortages in the field of engineering. Thus, engineering candidates with needed skills can be offered somewhat higher special beginning salaries in grades GS-5 through GS-11 (between $17,387 at Step 10 of the GS-5 level and $26,959 at Step 4 of the GS-11 level), depending on their education and experience. Their advancement then follows a modified GS schedule, which credits the higher entry-level salaries. Even in such special cases, however, federal salary offers are still appreciably--sometimes as much as 20 percent--below those of industry for the same engineering candidates. The Department of Defense Laboratory Management Task Force recently compared salaries of engineers in U.S. Department of Defense (DOD) laboratories with those of engineers in the private sector. Three facts are evident from this comparison: (1) the average industry salaries for engineers exceed those in DOD laboratories at all levels of duties and responsibility, (2) the salary differences are particularly great for beginning personnel, and (3) from 1977 to 1981 the average salary paid to scientists and engineers dropped in real terms by almost 13 percent in DOD laboratories, but by only 7.3 percent in industry (see Appendix G, U.S. Department of Defense Laboratory Management Task Force, 1982).

While salary limitations are a problem in recruiting and retaining Army scientists and engineers, they are not a problem with regard to physicians, for whom the Army has established a special pay scale. Army medical research and development laboratories are thus generally able to recruit physicians of high quality. Despite this positive note, Army medical institutions still must

adhere to the regular federal salary schedule in establishing salaries for professionals with other skills.

Merit pay, as it is implemented by the federal government, is almost universally condemned by both managers and bench personnel. The committee was repeatedly told that the system requires much time and paperwork of both the employee and the supervisor and at the most produces only marginal rewards (annual pay increases of approximately 3 percent) to a few select employees.

Recruitment

Army laboratory managers use a number of effective recruitment tools. One is its popular "co-op" program with universities, in which selected undergraduate students alternate quarterly between working at the laboratory and attending their classes. This program provides financial benefits and work experience to promising students and allows them to become familiar with the laboratory and its staff, which may dispel reservations the students may have about working for the federal government.

A second recruitment tool is the Army's intern program, in which beginning scientists and engineers (at GS-5 and GS-7 levels) are virtually assured of rapid promotions (to GS-9 and GS-11 or GS-12 levels) within 3 or 4 years of beginning at the laboratory. While this program does much to compensate for low beginning salaries, it can also frustrate those who are quickly promoted to GS-12 but who then must remain at this level for an indefinite period of time because there are few high-grade positions. Also, because of such rapid promotions, some professionals may not have the opportunity to gain fundamental research and development skills.

In addition to these recruitment methods, the Army also visits colleges to recruit. Unlike the non-Army laboratories, however, Army laboratories usually do not reimburse job candidates for expenses incurred in traveling to interviews at the laboratory. This fact apparently owes to the inaccurate perception of some laboratory managers that the Army disallows such reimbursements.

Compared with their counterparts in private research laboratories, Army laboratory managers must spend an

inordinate amount of time to recruit and hire personnel at various levels. DOD's Laboratory Management Task Force reported that it takes an average of about 9 months for an Army facility, including Army laboratories, to hire a GS-5 or GS-7, and about 5 months to hire a GS-13 or GS-15. For senior executives, the process can take as long as a year and a half. (These figures refer to the time needed to complete all aspects of recruitment, from the time the formal decision is made that a person is required to the time when the selected individual reports to work.)

Promotion

Promotion rates are highest in Army laboratories at GS-9 and GS-11 levels (See Appendix G, U.S. Department of Defense Laboratory Management Task Force, 1982). They are signficantly lower at the GS-12 level and above because there are fewer high-grade positions (GS-13 through GS-15) available to each laboratory than there are candidates for promotion. As was previously mentioned, one Army program exacerbates this situation: participants in the intern program that promotes promising young scientists and engineers quickly to the GS-12 level subsequently find further advancement difficult. The DOD task force reported that, on the average, personnel remain at the GS-12 level for 13 years, and not all GS-12's are promoted. The same limitations on high-level positions make it difficult for managers to hire high-quality scientists and engineers at the GS-12 and GS-13 levels.

Army managers can promote outstanding technical personnel through a "dual ladder" system comparable to that used in the non-Army laboratories, without requiring that these personnel assume greater managerial duties. Four of the Army facilities visited during the course of the study--the Mobility Equipment Research and Development Command (MERADCOM), the Engineer Topographic Laboratories (ETL), Picatinny Arsenal, and the Electronics Technology and Devices Laboratory (ET&DL)--all use the dual ladder system to a limited degree. The few nonsupervisory senior scientists and engineers who were promoted under this system at these laboratories are making important technical contributions to their fields and are enhancing the reputation of their respective research and development institutions. Because several high-level nonsupervisory

positions exist at these laboratories, the possible recruitment of high-quality professionals is greatly improved. Nevertheless, the rigid interpretation of such promotion regulations by local civilian personnel makes their use extremely difficult. Dual-ladder promotions at some laboratories are also curtailed because high-grade positions are limited and supervisory positions have first priority.

Termination

Laboratory staff reported that federal civil service regulations for terminating the employment of marginal or unsatisfactory employees are so cumbersome, time-consuming, and protective of employees' rights that they are rarely, if ever, utilized by Army managers. As a result, the supervisor of a marginal employee often assigns him or her to minor duties to limit any ill effect on the laboratory's performance. This failure to manage the issue properly damages the morale and productivity of other workers and wastes laboratory resources.

Personnel Administration

At some Army installations, a civilian personnel officer serves several laboratories and other agencies and reports to an official other than the laboratory director. This arrangement can result in the personnel officer's failing to satisfy laboratory directors' needs. In effect, these officers are often motivated by regulations and by those to whom they must report rather than by the laboratory's goals.

CONCLUSIONS

Beginning salaries at Army laboratories are significantly lower than those in industry. As a result, the Army is a noncompetitive employer in a number of specialty areas. To compensate for low beginning salaries, Army policy is to promote new laboratory employees very rapidly to GS-11 and GS-12 levels in their first few years of employment. This policy has several negative results: eliminating promotions based on performance in the first few years,

forgoing the important management practice of rewarding excellence and hard work, making it difficult to urge new employees to leave the laboratory if they are not suited for the work, and encouraging a disproportionate wait for promotion among employees at the GS-12 level.

The current merit pay system, as now implemented in Army laboratories, is judged totally ineffective and detrimental to morale by laboratory managers and bench scientists and engineers alike.

Some Army laboratories do not recruit actively on campus, and even more of them do not bring potential employees to the laboratory for interviews. Both of these practices are judged essential by industry and by many other successful research and development organizations.

The Army's intern and cooperative education programs are commendable and are frequently mentioned as important in recruiting and retaining personnel. The relations these programs establish with colleges and universities contribute to the prestige of Army laboratories and aid in hiring.

Almost every organization is pyramidal--there are relatively few positions at the top. Promoting through a dual-ladder system in laboratories can help obviate some of the problems this arrangement can promote. Nevertheless, the Army laboratories promote by means of the dual-ladder system only in very rare instances. This may result because high grades are mostly in management rather than in research and development, and because many high grades appear to be retained by higher headquarters rather than being passed along to the laboratories where the research and development work is done. Also detrimental to Army laboratories is retaining marginal employees simply because termination procedures are burdensome and time-consuming.

Finally, if local personnel officers are not responsive to the laboratory's personnel needs, the quality of new employees and the timeliness of personnel actions are greatly diminished.

RECOMMENDATIONS

o The federal pay system should be amended by the Congress to permit higher beginning salaries for new graduates possessing unique and needed skills so that these salaries are competitive.

o The Army should pay and promote in order to reward performance rather than to solve other problems (e.g., low beginning salaries).

o The Army should review employee performance within the first 2 years to determine the benefit of continued employment.

o Army laboratories should interview potential candidates at selected universities and should use professional staff rather than personnel officers in interviewing. This practice should be established as an obligation of the professional staff in pursuing their own long-term interests.

o Job candidates should be brought to Army laboratories to see the work place and meet potential colleagues. The Army should reimburse candidates for the expenses incurred by such interviews.

o The Army should modify its hiring procedures to allow a job offer to be made shortly after an interview when necessary in the view of the responsible scientific staff officer.

o Laboratory managers should continue to use the special recruitment programs and practices that they now do (e.g., cooperative education, summer employment of students, and establishing communication with universities).

o The Army should ensure that local personnel officers are more responsive to the personnel needs of the laboratory to which they are assigned. One approach might be to have such managers report to and have their performance evaluated by the laboratory directors rather than by authorities outside the laboratory. Such a practice would still allow the Army's personnel staffs to set broad personnel policy, as well as to review the effectiveness of each laboratory's personnel operation.

o To the full limit of its authority, the Army should implement the federal merit pay system in its laboratories in order to provide greater rewards to more personnel with less administrative effort and paperwork. If this is not possible, the Army should recommend to the administration and to the Congress appropriate legislative changes in the federal merit pay system.

o Army laboratories should maintain and emphasize the "dual ladder" promotion system in advancing scientists and engineers.

o If beginning salaries are increased for those with unique or needed skills, Army laboratories should, in

general, slow the rate of promotion for scientists and engineers between the GS-5 and GS-12 levels.

POLICIES CONCERNING PROFESSIONAL GROWTH AND RECOGNITION

OBSERVATIONS

Non-Army Laboratories

Training and Continuing Education

Both the management and staff of the four non-Army laboratories visited by the committee believe that the opportunity for professional growth is central to an environment that fosters high-quality research and development. The management of these laboratories supports the creativity of its personnel, encourages them to attend meetings and symposia, and in other ways attempts to contribute to their professional growth and expression of talent. During fiscal year 1982, for example, the Naval Research Laboratory (NRL) supported the publication of more than 870 papers in refereed journals, and provided opportunities for its staff to participate in short courses, seminars, and conferences. Other educational opportunities available to NRL staff include advanced graduate work, sabbaticals, and on-the-job training. At the laboratories of International Business Machines Corporation (IBM), staff are offered courses on IBM-related material and a part-time graduate work-study program, for which employees receive limited time off and full salaries. Oak Ridge National Laboratory (ORNL) strongly supports its in-house continuing education programs for scientific and technical personnel and analogous programs for those in management, administration, and technical support.

Incentives and Awards

The professionals at the four laboratories consider their incentive and awards programs effective and, for the most part, fairly administered. About 16 percent of IBM's employees annually receive informal awards of up to $2,500; for outstanding service, a few are given awards that can be as high as $100,000. At IBM, a popular award used frequently by laboratory managers is the "Dinner-for-Two" award. NRL managers give invention and patent awards, and bonus awards for senior executive service. The incentives and awards administered by NRL are comparable with those available to Army laboratory managers.

Army Laboratories

Training and Continuing Education

Opportunities for professional exchange and training at Army laboratories are generally excellent, although participation rates vary significantly among the laboratories. Laboratory staff have the opportunity to engage in a wide variety of short-term training programs, as well as in longer-term programs (those continuing more than 120 days). The Army usually pays all program costs, including, for example, the full salaries and benefits of professionals while they are attending school. Most Army laboratories that conduct basic research and development in-house encourage their staffs' publication of results in technical journals and their presentation of papers at technical symposia insofar as appropriate funds are available. In fiscal year 1982, laboratory staff at Walter Reed Army Institute of Research (WRAIR) presented nearly 200 scientific papers at regional, national, and international meetings, and published more than 170 journal articles. Some laboratories (e.g., the Engineer Topographic Laboratories) allow professionals to use the laboratory's computers at home for work during off-duty hours. Because all such activities help professionals keep up with the state of the art, these activities usually bring favorable recognition to the participating laboratory at the same time that they motivate employees.

Incentives and Awards

Most of the Army laboratories visited also use cash awards to recognize good work. Laboratory managers have the authority to approve cash awards of up to $2,500 for individual or group achievements. However, some laboratory staff noted that awards of comparable value that require detailed justification and approval at higher levels and lengthy processing time sometimes seem not worth the effort. A few bench-level professionals stated that some managers at mid-level and above are not technically qualified to identify exceptional scientific accomplishments. (See Chapter 3 for a more thorough discussion of the quality and effectiveness of Army laboratory leadership.) As a result, they believe that some awards are not made fairly or consistently.

CONCLUSIONS

Professionals in both Army and non-Army laboratories say that opportunities for graduate schooling and on-the-job training were important reasons for joining their laboratories. Other strong incentives that their management provide are encouraging publication of research and development, authorizing participation in technical conferences, and encouraging their communication with peers at other institutions. Most laboratory managers and bench-level workers agree that a very effective means of recognizing exceptional work is through locally approved cash awards.

RECOMMENDATIONS

- o The Army and its laboratory managers should continue to encourage graduate training for its professionals, publication of their significant research and development results, their participation in technical conferences, their communication with peers at other institutions, and their job mobility within and among laboratories.
- o Laboratory directors should emphasize immediate cash awards that senior and middle managers can give to their personnel to recognize merit in work when the managers judge it appropriate.
- o The Army should streamline its award procedures, for example, reducing the amount of paperwork and the

number of signatures required to process cash awards of more than several thousand dollars.

o An awards advisory board should be established by each laboratory director to help the management team judge the technical merit of the work of potential award recipients and to ensure an equitable distribution of awards.

6

RESOURCES

OBSERVATIONS

Non-Army Laboratories

Equipment and Support Staff

All four non-Army laboratories visited appreciate the importance of providing resources adequate to support their professionals. Management clearly understands that a lack of appropriate research tools forces scientists and engineers to work below their optimal levels of productivity and efficiency. As a result, management at these laboratories makes every effort to provide and maintain adequate support resources: libraries, laboratory supplies and equipment, and large and small computer facilities.

All of the laboratories visited greatly emphasize the importance of acquiring new equipment. The laboratories of International Business Machines Corporation (IBM) and the Oak Ridge National Laboratory (ORNL) are quite successful in doing so. ORNL normally invests approximately 7 percent of its operating funds in items of capital equipment costing $3,000 or more. The Naval Research Laboratory (NRL), along with other government laboratories, is less fortunate in this area, devoting 3 to 4 percent of its budget to such equipment.

Laboratory professionals report that technical support (e.g., in the form of technicians and computer programmers) is ample at the two IBM facilities, but well short of optimal at NRL and ORNL. Both management and staff report that these two organizations are loath

to commit limited funds to hiring necessary technical help, and instead hire scientists when they have an opening. (The present study did not address in depth the effectiveness of the laboratories' support organizations such as shops, stores, analytical laboratories, mailrooms, and purchasing departments. The report does highlight, however, a few deficiencies in those areas that the committee believes require immediate management attention.)

Funding of Projects and Programs

These research institutions, of course, realize that funding must be adequate to achieve program goals, and it must be available so as not to disrupt the laboratory's work. At the IBM laboratories, NRL, and ORNL, negotiations between the laboratory director and higher headquarters take place frequently to ensure that any anticipated decline in funding is gradual, has a long lead time, and is not capricious.

Size of Research and Development Groups

Managers at these institutions believe that the research and development divisions and groups of a scientific organization must be of sufficient size and must have an appropriate mix of skills to make significant advances. They are usually able to ensure that such criteria are met.

Army Laboratories

Equipment and Support Staff

The facilities and equipment at the Army laboratories visited vary from excellent to marginal. State-of-the-art equipment is used at the Electronics Technology and Devices Laboratory (ET&DL) at Fort Monmouth and at the Engineer Topographic Laboratories (ETL) at Fort Belvoir. At the Energetic Materials Laboratory at Picatinny Arsenal's Large Caliber Weapons Systems Laboratory, obsolescent and inadequate facilities have been upgraded in the past 5 years and are now providing laboratory professionals necessary support. At one Army

laboratory visited--the Materials Laboratory at the Mobility Equipment Research and Development Command (MERADCOM)--the facilities were found to be inadequate for the laboratory's mission and in need of immediate and extensive upgrading. Reference libraries at most Army laboratories visited seem satisfactory to support the immediate needs of the staff in carrying out research and development.

In many Army laboratories, the nonprofessional support staff is not accountable to the scientists and engineers it supports. Researchers find that this fact, coupled with the lack of adequate personnel of other kinds (e.g., technicians and computer programmers) greatly inhibits work progress. Sometimes when laboratories cannot obtain needed expertise in-house, they contract for it.

Professionals report that procurement and housekeeping support in Army laboratories are generally inadequate and contribute to poor morale. Scientists and engineers at a number of Army laboratories visited (e.g., the Walter Reed Army Institute of Research [WRAIR]) report that major pieces of equipment and computer systems are relatively easy to justify and acquire, but that small pieces of equipment such as personal computers are not. The process of acquiring equipment for Army laboratories is lengthy. At one laboratory the procurement of relatively routine, expendable supplies required more than 13 months. By the time the supplies had arrived, the researcher had improvised with less satisfactory substitutes. Some laboratories also lack appropriate space to store such supplies.

Since all new military construction projects of over $100,000 compete against each other for funds during the appropriations process (when the need for new research and development facilities may be weighed, for example, against the need for training facilities and/or military hospitals), the actual approval and construction of requested laboratory facilities often lags far behind the need for them. As a result, existing laboratories often have to accommodate new equipment and personnel in insufficient space until construction is complete.

Funding of Projects and Programs

The adequacy of funds available to Army laboratories varies from institution to institution and from program

to program within institutions. At WRAIR, for example, both management and staff report that funding is sufficient to meet current mission requirements. At the same time, both managers and researchers at WRAIR said that their jobs would be much easier if more funds for basic research were allocated to the laboratory. Such funds can be spent more flexibly and require less paperwork and monitoring than monies for development work. Natick Research and Development Laboratories (NLABS) has more severe funding problems. Because of changes in congressional budget appropriations as well as in Army priorities, funds have been dramatically redistributed among research and development areas and some of NLABS's long-term projects have been discontinued.

Given the appropriations process and the changing requirements of their users, Army laboratory directors realize the importance of constant communication and negotiation with higher Army headquarters. Their success in this endeavor and their ability to keep their staffs abreast of their efforts greatly affects the research and development environment and the productivity and effectiveness of their laboratories.

Size of Research and Development Groups

Although Army laboratory directors try to match the size of their technical teams with the demands of newly assigned tasks, the organizational and manpower structures at the laboratories allow little flexibility in this regard. Any changes to the laboratory Tables of Distribution and Allowances (TDAs) must be approved at higher headquarters. The number of full-time personnel and the funds with which to pay them are also tightly controlled, each by a different element of the higher headquarter's structure, resulting in even greater inflexibility.

CONCLUSIONS

Without appropriate resources and support, scientists and engineers cannot be optimally productive. A few laboratories lack stockrooms, and thus acquiring minor equipment in these laboratories becomes a large issue that delays the completion of a project and that can seriously affect morale. Unreasonably long lead times

required to purchase equipment are wasteful and demoralizing. Professional and technical personnel working with state-of-the-art equipment and in modern facilities exhibit a great deal of pride in their research and development institutions. The difference in the morale and confidence of individuals working in up-to-date laboratories and those working in poorly equipped and maintained laboratories is striking. A professional environment that promotes creativity and productivity is one with resources appropriate for its personnel and mission.

The effectiveness of an organization is also related to its director's ability to assemble a group of individuals of sufficient size and appropriate skills to address difficult engineering and scientific problems and then to redistribute these individuals when solutions have been found.

RECOMMENDATIONS

o The Army should update its substandard laboratory facilities. Laboratories with substandard plant and equipment should be supported by Army headquarters in Army budget requests to the Congress for the funds necessary to improve their facilities so that their professionals can successfully meet mission requirements.

o A certain fraction--5 to 10 percent--of Army laboratory operating costs should be allocated to acquire research and development equipment costing approximately $3,000 or more. This fund should be programmed and budgeted by laboratory directors, and should not compete with that for general equipment such as cars and trucks, machine tools, and cranes. Funding mechanisms currently available to the laboratory director (i.e., project monies or funds provided for the In-House Laboratory Research Program) are considered insufficient for equipment purchases of this magnitude.

o Army stockrooms should be able to provide frequently used small supplies as well as moderately priced modern equipment (e.g., hand calculators), as in other research and development institutions.

o Lead times for procuring equipment should be drastically shortened through more liberal interpretations of procurement regulations or through their actual revision, and procurement offices should be held accountable for delays.

o Laboratory directors should review the distribution of their staffs to determine whether the ratio of technical to professional personnel is appropriate for the mission of their facilities.

o To minimize the influence of funding changes on achieving laboratory program goals, the Army should provide its laboratories a given amount of funds per year to allow them more flexibility in core programs. The Office of Naval Research, for example, has agreed in principle to support a certain number of NRL's technical man-years per year (approximately 450) to allow it this flexibility.

o To maintain an adequate mix of technical skills and experience, the Army should press for changes in those policies affecting personnel actions and laboratory manpower allocations so that research and development teams can be properly balanced. The experience and expertise of team members will then match job requirements. However, before this can be accomplished, Congress will need to amend Title V, United States Code, Chapters 55 and 56 to provide a mechanism for incorporating personnel policy changes--such as those related to job classifications and reduction-in-force (RIF) procedures--across the board. Actions to modify the laboratories' manpower allocations could be achieved within the current Army structure.* Changes in these two areas would provide the Army and its laboratory directors more flexibility in hiring and moving personnel to match the funded workload.

*In the early 1970s, the Secretary of Defense established Project REFLEX in which 10 laboratories (4 Army, 3 Navy, and 3 Air Force) were authorized to modify their manpower allocations as required, without obtaining prior approval, to match their funded workload. This experiment in added management flexibility produced many positive results that should be applied with appropriate modifications to today's Army laboratories.

RESEARCH AND DEVELOPMENT PROGRAMS

OBSERVATIONS

Non-Army Laboratories

Program Content

Important features of the professional environment include program content and the ratio of research and development undertaken in-house to that contracted. These influence both a laboratory's ability to attract and acquire quality scientists and engineers and its ability to maintain a strong scientific base from which to engage in contracting. All the non-Army laboratories visited strive to maintain a strong in-house research and development program. A policy of the Oak Ridge National Laboratory (ORNL), for example, is that it will not subcontract any project without devoting at least 15 percent of the project's funds to research and development in-house. Likewise, the Naval Research Laboratory (NRL) and all other Navy laboratories are subject to the general rule that a significant and substantial fraction of funding must be spent in-house for reimbursable orders for research and development.

Program Stability

The laboratories of ORNL, NRL, and those of International Business Machines Corporation (IBM) consider work stability as well as the reasonable apportionment of work essential for productive research and development. Representatives of their parent

organizations meet frequently with their management teams to discuss any anticipated changes in program priorities, structure, or funding. They also try to avoid apportioning excessive work to the research and development organization, since this would result in inadequate products, staff frustration, and poor performance. Laboratory management knows that work must sometimes be refused and is free to do so at the four institutions visited.

Program Review and Impact

The criteria used in judging the laboratory's performance form another important part of research and development program management. While many organizations establish unrealistic performance criteria, such as evaluating divisions and programs against 100 percent completion of their previously established goals, IBM and ORNL feel that such an approach is inappropriate for a research and development organization. Instead, these laboratories strive for at least 80 percent achievement. Managers at these two laboratories also believe that very significant benefit is derived from an evaluation that identifies why goals are not achieved. If identified problem areas are addressed and resolved, an improved operation can result.

ORNL uses several different procedures to monitor its performance at each organizational level. The evaluation systems for personnel include annual performance reviews and peer reviews of individual technical contributions. The research and development divisions and programs are monitored and evaluated through division meetings, program reviews by sponsors, reviews by various advisory committees, and peer reviews of the basic science program (made every 3 years). The laboratory itself is also reviewed through annual evaluations by its Management Advisory Council, through quarterly management reviews of its major goals and obligations, and through staff analyses.

Army Laboratories

Program Content

In Army as in non-Army laboratories, providing researchers with the opportunity for engaging in

challenging in-house research and development is seen as necessary for attracting and retaining talented, motivated professionals. Most of the Army laboratories participate in such programs as the In-House Laboratory Independent Research Program (ILIR).* The mission requirements of some laboratories lead them to be more oriented than others toward in-house research and development. For example, few industries conduct research and development that supports the products (e.g., cannons) of the Armament Research and Development Command (ARRADCOM). ARRADCOM laboratories at the Picatinny Arsenal report impressive recruiting success at nearby colleges and universities, much of which they credit to the hands-on research and development work they can offer. At the same time, procedures set forth by the Office of Management and Budget in its Circular A-109, which requires federal agencies to contract out work wherever possible, have resulted in an Army implementation policy directing Army laboratories to make maximum use of outside contractors for research and development. The result of this policy is that Army laboratory scientists and engineers increasingly oversee contracted work rather than participate in it. These professionals thus lose the opportunity to gain skills in research and development and in the ability to evaluate and manage research and development.

The Army further limits in-house research, development, and application opportunities for its laboratory scientists and engineers by allowing all project managers, who are located at different command headquarters, to establish their own technical support teams. This project management staff tends to work on difficult problems of high-priority systems. To address such problems, this staff must be highly skilled and experienced. Since high-grade positions on these staffs are often made available to personnel with rare or needed skills, talented professionals often leave the Army laboratory system to join a project manager's team. The committee learned that this flow of talented

*ILIR provides "seed money" for in-house, bench-level research. The funds are provided directly to the laboratory's technical director by the Assistant Secretary of the Army for Research, Development and Acquisition on a competitive basis and are based on an annual advisory committee's review of the quality of ILIR work at that laboratory during the previous year.

professionals from the laboratories--at least from those visited by the committee--to project teams was becoming more and more of a problem for laboratory managers, since the expertise and experience of those leaving the laboratories were often difficult to replace.

Program Stability

Again, maintaining continuity in laboratory research and development programs, along with balancing work assignments, is critical to the effectiveness of both the laboratory as a whole and the researcher in particular. Like the managers in non-Army laboratories, those in Army laboratories exert a great amount of effort to sell their ideas and programs to higher Army headquarters. This communication process with the various command organizations, and within the laboratories themselves, improves the chance that any changes in program direction or requirements will be gradual and will have a long lead time. However, shifting requirements resulting from changes in command personnel and in Army priorities--as well as those introduced by the appropriations process--lead to discontinuity in the research and development programs of some Army laboratories and to the elimination and the initiation of programs at others.

At some of the Army laboratories visited, program instability has been a serious problem. For example, over the last 5 years the Natick Research and Development Laboratories (NLABS) have had numerous changes in program direction, which have caused periods of low morale and productivity and have greatly diminished the effectiveness of the research and development program. Researchers in some of NLABS' divisions have had to move from one project to another, and in some extreme cases from one program to another, to remain funded and employed. Reasons for such instability have been both internal (NLABS had no technical director for more than 2 years) and external (budgetary cuts and changing Army priorities). In the last several years the Large Caliber Weapons Systems Laboratory (LCWSL) has also had periods of program instability and changes in the type and amount of research and development that is undertaken in-house. Management at both NLABS and LCWSL now appear to be working with their laboratory professionals--for example, in conducting in-house reviews--to impart some

stability and direction to their research and development programs and to improve their products.

Program Review and Impact

Personnel in all the Army laboratories visited have a strong desire to undertake challenging work and to achieve solutions to their users' problems. Frustrations occur, however, when laboratory personnel try to determine what their users actually want and, in some cases, who their users really are. Officers assigned to represent the users of the laboratories' products at the Training and Doctrine Command (TRADOC) normally serve tours of duty of 2 to 3 years, so that there is little continuity in the representation. This change in personnel results in frequent changes to the system requirements governing a laboratory's efforts. Further complicating the situation is the ever-decreasing proportion of Army laboratory personnel who have served in the military. Given the continuing shortage of qualified military officers assigned to the laboratory system, this trend is eroding Army laboratories' appreciation of the field environment and understanding of such important factors as the implications of logistics for design.

CONCLUSIONS

Program content, the ratio of research and development work undertaken in-house to that contracted, and the stability of the research and development program are all factors that greatly influence a laboratory's professional environment and affect its success in attracting and retaining talented, motivated individuals. The committee believes that, while a limited amount of program reevaluation and redirection is essential to the vitality of a research and development organization, constant program changes are the result of poor planning by management at the laboratory and at higher levels.

Effective communication with laboratory clients is essential to ensuring that research and development results are relevant. The ability of Army laboratories to communicate effectively with their user community is hampered by the constant change of military personnel at command organizations, such as TRADOC. With such change the research and development requirements frequently

change, since individuals often define and interpret requirements a bit differently from one another. Customer satisfaction is an important goal of any user-oriented organization. When frequent changes in the requirements occur, it becomes difficult to produce results that meet the customer's real needs.

RECOMMENDATIONS

- To maintain required technical expertise and environments that produce high-quality research and development, Army laboratories should operate under the general rule that a significant percentage--for example, more than half--of their basic research and exploratory development should be performed in-house.
- The Army should restrict project managers' staffs to primarily administrative roles, which would depend on the laboratories for technical support.
- To provide more continuity, the Army should assign a mix of highly trained civilians and military officers to central positions in Army organizations charged with establishing and changing requirements. TRADOC headquarters and centers should be encouraged to establish civilians as deputies to military decision makers in the community developing requirements. This would help establish more effective communication with senior laboratory managers, would diminish the adverse effects of the frequent reassignments of military officers, and would minimize changes in research and development requirements.
- Laboratory managers should be encouraged to discuss with higher headquarters the pros and cons of accepting a new work assignment if in their opinion it is unsuitable to their organization, is technically unsound, or depletes their resources at the expense of more important work.

8

FUTURE TRENDS

The preceding chapters have offered a number of recommendations. Of these, the committee found several especially significant:

- o Appointing and reappointing laboratory directors solely on the basis of their special training for the role;
- o Maintaining research and development units of sufficient size composed of scientists and engineers in an appropriate distribution of specialties;
- o Encouraging the "dual ladder" system of promotion so that professionals can advance in either research and development or management;
- o Offering better beginning salaries to candidates of high promise;
- o Changing the merit pay system so that it provides better rewards and imposes fewer burdens;
- o Increasing the use of immediate cash awards to recognize merit in work;
- o Ensuring that the laboratory equipment and plant are sufficiently modern to meet mission requirements;
- o Moderating the trend toward contracting important projects.

These changes would improve the professional environment for scientists and engineers in Army laboratories to match that of the best Army and non-Army laboratories the committee observed.

Failing to implement these recommendations will not immediately affect the quality or productivity of the Army research and development laboratories; nor, for that matter, will heeding them. This is a consequence of the committee's focus on trends influencing the Army laboratories over the long term rather than on specific,

short-term problems. Some of the long-term trends identified were disturbing: reduced productivity, declining morale, a diminishing Army laboratory capability to do in-house research and development, and an increasing tendency on the part of Army higher headquarters to micromanage laboratories' programs and resources. The committee believes that its recommendations, if heeded, will go a long way toward reversing these undesirable trends and towards ensuring that Army laboratories can fulfill their future missions. This conclusion must be qualified, however, by a few general observations.

The Army research and development laboratories, like those in other services, elsewhere in the government, at universities, and in private industry, do not operate in isolation. They are part of, and therefore are influenced by, the political, economic, and social systems of the United States. As these systems change, so does a laboratory's environment. This environmental change can have beneficial or adverse effects on laboratory operations. With regard to the likely environment of Army laboratories in the future, three points are particularly important to consider. First, demographic shifts will create hiring and promotion difficulties for all organizations through the next decade or two. Second, there is a potential imbalance nationally between the supply of technical personnel and the demand for their services. Third, and in a somewhat different category, there is the national plan to update and expand the Army generally.

DEMOGRAPHY

The peak of the postwar baby boom in the United States occurred in 1961, when 4,350,000 babies were born. This produced a corresponding peak in the number of young workers over the past few years. During the next decade or so, two changes in this picture will be seen: (1) the supply of new workers will diminish, perhaps quickly and profoundly enough to cause isolated shortages; and (2) the population of employees in mid-career who expect promotions and other recognition will increase. The Army laboratories will of course be subject to these changes, even though regional variation in demographic trends will delay these changes in some locales (see Appendix G, Jackson et al., 1981b). The

first new trend accounts in part for the current shortage of technicians and other support staff. The second also presents problems, given the limited number of high-grade positions available. With allocations for personnel unlikely to increase, this combination of shortages--promotion opportunities and new workers--will present a dilemma. It will be difficult and unwise to shift to recruitment purposes the resources devoted to current workers (for example, merit raises and subsidies for education and professional travel). At the same time, the market for beginning technicians, engineers, and scientists will be competitive enough to prohibit reallocating any current recruitment funds to employees. Only if the laboratories grow significantly and such expansion results in an increase in available laboratory high-grade positions would this conflict between hiring and promotion be somewhat mitigated, but even then it would not disappear.

LABOR SUPPLY AND DEMAND

Much has been written recently about the projected labor shortages in certain technical and scientific fields, particularly in computer science and microbiology. The potential extent of these projected shortages and the question of whether they represent a short-term or long-term trend are controversial topics. So are its regional variations. When supply and demand actually have similar values in a given technical field, the mere appearance of a shortage can have deleterious effects through a competitive labor market. For example, if both the Army and game manufacturers need designers of microchips, which is not unlikely, and if there appears to be a shortage of designers, the game manufacturers will raise the salaries they offer to ensure that they get the help they need. All microchip designers will expect such high salaries, and the Army will either have to increase its salaries (as it has for physicians) or hire those who will work for less.

ARMY PLANS

The third environmental factor that will influence Army laboratories over the next few years is the Army itself, and particularly the ways in which its technical needs

evolve. A developmental plan that emphasized new, high-technology weapons and sophisticated vehicles would have very different implications for Army laboratories than would a plan emphasizing low-technology systems. Obviously the Army's development plan will emphasize both areas to some degree, and the laboratories will respond accordingly. The point here is that any changes in the Army's plans will have a substantial impact on their laboratories' effectiveness. It will be more profound on some laboratories than others. Of more concern, as was mentioned earlier, is the cumbersome mechanism by which Army doctrine influences laboratory missions and projects; in a time of changing doctrine, a slow response on the part of laboratories will prove particularly problematic.

In light of the factors discussed above, what can the Army laboratories expect over the next few years? The committee anticipates that they will confront three problems. First, the Army's rather cumbersome procedure for hiring and promoting civilian staff, discussed earlier, along with demographic trends will produce a shortage of technicians and other beginning workers and a frustrated group of workers who are in mid-career. Second, the belief that there is a shortage of scientific and engineering personnel and that non-Army laboratories capture the best of these will undermine morale at Army laboratories. (The committee's visits gave ample evidence of this.) Third, greater and more specific demands will be made on Army laboratories in light of the Army's programs, particularly in those areas correspondingly to basic research. Without correspondingly rapid changes in laboratory capabilities, the net effect of these problems will be to make Army laboratories less productive. And unless the Army takes strong action, this lack of productivity will be the beginning of a serious trend, which will finally result in an ineffective laboratory system whose mission must be performed by outside contractors.

Beyond the committee's specific recommendations, what actions should the Army take? Before this question is answered, the two problems of personnel and morale require comment. These problems, unlike many of those documented in earlier chapters, stem not from Army actions, but quite directly from the larger political, economic, and social forces affecting Army and non-Army laboratories alike. A recent study of the city of Boston's economic prospects, for example, pointed to

many of the same difficulties (see Appendix G, Doolittle et al., 1982). The Army's plans to grow and to update their systems exacerbate these problems. The obvious solutions to both--increasing the number of promotion opportunities for existing workers, increasing the funding available to hire new employees, delaying or forestalling change--are all impractical. The Army, like other employers facing these problems, must respond creatively by rearranging incentives (including working conditions, educational benefits, etc.), by making flexible use of the existing workforce, by fully exploiting labor-saving technologies (such as computers), and by maintaining management and reporting chains that can respond quickly and flexibly to changing needs. The question for management to ask is not so much "Where will we get the new people we need?" (since they are likely to be unavailable) as "How can we retain and use our current resources more effectively?" Many of the committee's recommendations in earlier chapters speak indirectly to this point by stating that rigid personnel policies and management structures make creative response difficult. But the essential point, both here and as it has been made throughout the committee's report, is that flexible policies and structures will not in themselves solve the problem: they must be the basis for creative actions (such as those highlighted above) to strengthen the Army laboratories so as to attract, retain, and motivate the quality scientific and engineering laboratory staff the Army needs to carry out its mission. In summary, the committee is convinced that unless its recommendations are acted on with vigor and authority, the Army laboratories' ability to provide the essential technology base for equipping the future Army will be seriously impaired.

APPENDIX A

STATEMENT OF TASK

The committee will assess the professional environment and utilization of civilian and military scientific, engineering, and technical personnel in U.S. Army laboratories with the primary objective of identifying possible steps the Army could take to enhance the professional environment of its laboratories in order to better ensure mission requirements and high qualities of performance. The following tasks will be completed:

1. Characterize the professional environment for a selected group of non-Army government and private sector laboratories having reputations for general excellence and productivity (e.g., Oak Ridge National Laboratory, Naval Research Laboratory, International Business Machines) that conduct research and development similar to that performed in U.S. Army laboratories.

2. Selectively examine the professional environment in a number of U.S. Army laboratories representing a variety of mission requirements and qualities of performance.

3. Identify those factors in both sets of laboratories that are considered important for characterizing, identifying, attracting, and retaining high quality people. Comparisons and contrasts should be highlighted where data permit.

4. Among the significant characteristics identified, indicate those Army strengths that should be reinforced and those weaknesses for which corrective action should be undertaken. Provide a

corresponding action agenda with suggested approaches and priorities.

5. Relate these observations to probable impact on the Army during the decades of the 1980s-1990s if the Army does not initiate and maintain an intensive response.

6. Comment on secondary observations related to any aspect of Army scientific, engineering, and technical personnel--whether in the laboratories or not--which surface during the study.

7. Suggest methodology, key indicators, and the like suited for an evaluation system by which the quality of Army laboratory scientific, engineering, and technical professionals may be characterized by their output and value to the Army.

APPENDIX B

BIOGRAPHICAL SKETCHES, COMMITTEE ON ARMY MANPOWER

John W. Landis received a B.S. in Engineering Physics in 1939 and an honorary Sc.D. in 1960, both from Lafayette College. He has worked as a researcher, manager, and senior executive in various laboratories and engineering organizations--including Eastman Kodak, the Atomic Energy Commission, Babcock & Wilcox, Gulf Oil, and Stone and Webster Engineering Corporation, where he is currently Senior Vice President--and has been a major contributor to several professional societies. He is a founder and past president of the American Nuclear Society, and was instrumental in forming the Atomic Industrial Forum and in establishing and overseeing the national nuclear standards program under the aegis of the American National Standards Institute. He has served ANSI in many capacities, including as its president. He is a member of the National Academy of Engineering, a fellow of both the American Society of Mechanical Engineers and the American Nuclear Society, a director of the U.S. National Committee of the World Energy Conference, and a licensed professional engineer. His many papers include several on the effective utilization of scientific and engineering personnel.

John R. Bradford is currently Vice President for Development and University Relations of Texas Tech University, where he earlier served as Dean of the College of Engineering for 27 years. Dr. Bradford received his B.S. and M.S. in chemical engineering from Texas Tech University and his Ph.D. in chemical and nuclear engineering from the Case Institute of Technology. His industrial experience includes

positions with the Standard Oil Company, the Pan American Petroleum Corporation, the United Geophysical Company, and the United States Radium Corporation. Dr. Bradford is a registered professional engineer in Texas and Ohio and is former state director of the Texas Society of Professional Engineers. He serves on the Board of Directors of the U.S. National Commission of the World Energy Congress and served as a member of the U.S. National Commission to UNESCO.

Howard H. Cooksey retired as Lieutenant General from the U.S. Army in January 1978 following his last assignment as Deputy Chief of Staff for Research, Development, and Acquisition. He is now President of the Cooksey Corporation, a consulting firm that provides advice to U.S. and allied industry on defense research, development, and acquisition. He is also a member of the National Research Council's Committee on Army Robotics and Artificial Intelligence. General Cooksey earned his B.S. from the Virginia Polytechnic Institute in 1943, his M.A. in International Affairs from the George Washington University in 1964, and attended the National War College in 1963.

Nicholas DeWitt received his A.B. from Harvard College, and M.A. and Ph.D. degrees in economics from Harvard University. He is currently a Professor of Economics at Indiana University. He has written three books and more than 200 articles, chapters, and reports on topics of science education, training and utilization of professional manpower, and the economics of human resources in the United States, the USSR, and developing countries. He worked extensively as a consultant on these topics with U.S. federal and state agencies and as an advisor to the international organizations and governments in Europe, Asia, and Africa.

Peter L. Eichman received his M.D. from Jefferson Medical College in 1949, and trained in Internal Medicine and Neurology at Walter Reed Army Hospital and the Mayo Clinic. Since 1954 he has been a faculty member of the University of Wisconsin, serving seven of those years as both Dean of Medicine and Director of the University Medical Center. His current position is

clinician-teacher and researcher in neurology. From 1970 to 1972, Dr. Eichman served as Deputy Director of the Bureau of Health Manpower at the National Institutes of Health. He has also served as a consultant in the Federal Grants Review Process in the field of Health Manpower and Health Services Research and was a member of two National Academy of Sciences study panels on graduate medical education in the military and on biomedical and behavioral factors influencing the performance of airline pilots.

John W. Geils is Staff Executive of the American Society for Engineering Education, where he directs programs that address the shortage of college faculty in engineering. Previously, Mr. Geils was with AT&T, where he was Director, Network Department Administration. In this capacity he was responsible for the professional well-being of those in engineering jobs throughout the Bell System. Prior assignments at AT&T included managing Bell Telephone Laboratories' research and development programs funded by AT&T, Technical Suggestions Studies, and certain engineering personnel functions. Earlier at Bell Telephone Laboratories he was Assistant Vice President for Systems Engineering. Mr. Geils holds a B.E.E. from Rensselaer Polytechnic Institute and has attended Columbia University graduate school and Williams College advanced management programs.

Alfred Gessow is Professor and Chairman of the Department of Aerospace Engineering and Director of the Center for Rotorcraft Education and Research at the University of Maryland. He received his B.S. from the City College of New York and his M.S. from New York University. Most of his career has been spent in research and research administration at the National Aeronautics and Space Administration. He is the senior author of a widely used textbook on helicopter aerodynamics and has published many reports and technical articles on this and other aerospace subjects. He is a fellow of the American Institute for Aeronautics and Astronautics and is an honorary fellow of the American Helicopter Society.

Jerrier A. Haddad joined the International Business Machines Corporation (IBM) in 1945 in the Endicott

laboratory. He was initially a member of the IBM 604 development team and headed the IBM 701 engineering team. His later positions at IBM include those of manager of the Endicott and Poughkeepsie laboratories; Corporate Director of Technology and Engineering; Vice President for Engineering, Programming, and Technology; and Vice President for Technical Personnel Development. Mr. Haddad received his B.E.E. from Cornell University, where he now serves as chairman of its Engineering College Advisory Council. Mr. Haddad holds 18 patents for inventions in the computer and electronics field and has written and lectured extensively on engineering, scientific, and educational topics. He is a member of the National Academy of Engineering, and serves as chairman of the National Research Council's Committee on the Education and Utilization of the Engineer.

Gregory A. Jackson earned his S.B. at the Massachusetts Institute of Technology and his Ed.D. at Harvard University. He taught at Stanford University before assuming his present position as Associate Professor in the Harvard Graduate School of Education. Dr. Jackson's research focuses on students' decisions about whether to enter college and whether to complete degrees; on regional demographic and economic projections; on the ways colleges and universities make decisions to use technologies like computers; and on the development and evaluation of institutional and social policy in education.

Walter B. LaBerge recently joined Lockheed Missiles and Space as Executive Assistant to the President. In this capacity he works with division general managers and their staffs to develop new product lines and business growth strategies. Prior to joining Lockheed, Dr. LaBerge served as the Principal Deputy to the Under Secretary of Defense, Research, and Engineering, as corporate Vice President of the Defense Division of Philco-Ford, as Technical Director of the U.S. Government Naval Weapons Center at China Lake, as Assistant Secretary of the Air Force for Research and Development, as Assistant Secretary General of NATO, and as Under Secretary of the Army. Dr. LaBerge was one of the principal inventors of the Sidewinder missile and led the team that designed the NASA Houston Mission

Control Center for Apollo. He is one of the few scientists to have received medals of commendation from the U.S. Air Force, Navy, Army, and Department of Defense. Dr. LaBerge received his B.S. in science and Ph.D. in physics from the University of Notre Dame.

Bernard H. List holds B.E. and Ph.D. degrees in Electrical Engineering from the Johns Hopkins University. Since 1957 he has been with Texas Instruments, where he is currently a Vice President of Corporate Staff and Manager of Corporate Training and Education. Dr. List's experience at Texas Instruments includes management positions in Government Electronics and Semiconductor groups. He also conducted and managed research in the Corporate Research Laboratories. From 1971 to 1976, Dr. List was on leave from Texas Instruments, serving successively as Chief Scientist, Deputy Director, and Director of the Air Force Avionics Laboratory at Wright-Patterson Air Force Base. His last assignment at Wright Field was as Deputy Director of the Air Force Wright Aeronautical Laboratories.

William B. Taylor received his B.S. from the U.S. Military Academy in 1945 and his M.S. in Electrical Engineering from the Johns Hopkins University in 1951. For 9 years he served as an Army officer, including 4 years on technical projects related to nuclear weapons and power reactors. From 1955 to 1977 he served as engineer and manager in the Atomic Energy Commission, National Aeronautics and Space Administration, and in Army research and development positions at both laboratory and headquarters levels. As an engineering and management consultant since 1977, he has served government and industry in the United States and overseas, primarily in planning and analyzing energy systems and in analyzing management problems. He is a registered professional engineer in the District of Columbia and Virginia.

Harold P. Van Cott received a B.A. from the University of Rochester and M.A. and Ph.D. degrees in psychology from the University of North Carolina. He has held the positions Professor of Psychology at Alfred University; Supervisory Research Psychologist at the U.S. Naval

Medical Research Laboratory; Director of the Institute for Human Performance Research at the American Institutes for Research; and Chief of the Consumer Sciences Division at the National Bureau of Standards. He is now Chief Scientist at BioTechnology, a firm that conducts human factors research for government and industry. Dr. Van Cott has served as a consultant to the Ford Foundation, the Army Research Office, the Army Test and Evaluation Command, the Army Materiel Command, and the National Research Council. He is a Fellow of the American Association for the Advancement of Science; the American Psychological Association; the Human Factors Society; and the Washington Academy of Science; and is currently President of the Society of Engineering Psychologists of the American Psychological Association.

Alexander Zucker received a B.A. from the University of Vermont and M.S. and Ph.D. in physics from Yale University. For the past 10 years he has served as Associate Director of the Oak Ridge National Laboratory, where he earlier served as Director of the Heavy-Ion Project, Associate Director of the Electonuclear Division, and physicist. Dr. Zucker was a member of the National Academy of Sciences' Nuclear Physics Delegation to the People's Republic of China and of several National Research Council committees. He served as Executive Director of the Council's Environmental Studies Board. He has also been a U.S. delegate to the Pugwash Conference and a member of the U.S. delegation to the USSR on Peaceful Uses of Atomic Energy. His many publications in the field of nuclear physics include papers on nuclear reactions, ion sources, and accelerators.

APPENDIX C

SITE VISITS AND BRIEFINGS OF THE COMMITTEE ON ARMY MANPOWER

COMMITTEE SITE VISITS

November 22-23, 1982

Research Laboratory, U.S. Navy, Washington, D.C.
Walter Reed Army Institute of Research, U.S. Army, Washington, D.C.
Engineer Topographic Laboratories, U.S. Army Corps of Engineers, Fort Belvoir, Va.
Mobility Equipment Research and Development Command, U.S. Army, Fort Belvoir, Va.

December 14-15, 1982

Owego Engineering Laboratory, International Business Machines Corporation, Owego, N.Y.
Glendale/Endicott Product Laboratory, International Business Machines Corporation, Glendale, N.Y.

January 10-11, 1983

Oak Ridge National Laboratory, Oak Ridge, Tenn.

January 26, 1983

Research Institute of Environmental Medicine, U.S. Army, Natick, Mass.
Natick Research and Development Laboratories, U.S. Army, Natick, Mass.

February 16-18, 1983

Large Caliber Weapons Systems Laboratory, U.S. Army, Dover, N.J.
Fire Control and Small Caliber Weapons Systems Laboratory, U.S. Army, Dover, N.J.
Electronics Technology and Devices Laboratory, U.S. Army, Fort Monmouth, N.J.
Electronic Warfare Laboratory, U.S. Army, Fort Monmouth, N.J.
Combat Surveillance and Target Acquisition Laboratory, U.S. Army, Fort Monmouth, N.J.
Centers for Systems Engineering and Integration, for Communications Systems, and for Tactical Computer Systems, Communications Research and Development Command, U.S. Army, Fort Monmouth, N.J.

COMMITTEE BRIEFINGS

June 30, 1982

"Professional Environment at the Ballistic Research Laboratory." Presented by Dr. Robert J. Eichelberger, Director, Ballistic Research Laboratory, Aberdeen Proving Ground, Md.

"Concerns and Observations about Army Medical Research and Development." Presented by Colonel Harry Dangerfield, Deputy Commander, U.S. Army Medical Research and Development Command, Fort Detrick, Md.

"Professional Environment for Scientists and Engineers in the Army Corps of Engineers." Presented by Colonel M. I. Kovel, [Former] Deputy Director for Research and Development, U.S. Army Corps of Engineers, Washington, D.C.

"Overview of U.S. Army's Personnel Requirements, Procedures, and System." Presented by James Borden, Office of the Deputy Chief of Staff for Personnel, U.S. Army, Washington, D.C.

July 1, 1982

"Summary of Report of the Department of Defense Laboratory Management Task Force on Science and Engineers in Department of Defense Laboratories." Presented by Dr. Herbert Rabin, Deputy Assistant Secretary of the Navy for Research, Applied and Space Technology, Office of the Assistant Secretary of the Navy for Research, Engineering and Systems, Washington, D.C.

September 30, 1982

"Army Science Board 1982 Study on Science and Engineering Personnel." Presented by Dr. Alvin Eaton, Assistant Director of the Johns Hopkins Applied Physics Laboratory, Laurel, Md., and member of the Army Science Board.

March 4, 1983

"Conclusions of a Diagnostic Study of the Organizational Health of Army Laboratories." Presented by Mr. Eldon Sweezy, Senior Associate and Project Director, Institute of Public Administration, Washington, D.C.

APPENDIX D

COMMITTEE LETTERS REQUESTING PERMISSION FOR SITE VISITS

SAMPLE OF THE COMMITTEE'S REQUEST LETTER TO ARMY LABORATORY DIRECTORS

(Date)

(Addressee)

Dear :

The U.S. Department of the Army, through the Office of the Deputy Chief of Staff for Research, Development and Acquisition, has asked the National Research Council's Board on Army Science and Technology (BAST) to conduct an assessment of the professional environment and utilization of military and civilian scientists, engineers, and technical personnel in Army laboratories. In response to this request, BAST has established a Committee on Army Manpower whose primary objective is to identify possible steps which the Army could take to enhance the professional environment of its laboratories in order to ensure high qualities of performance and effective implementation of mission requirements.

The Committee will examine at first hand the professional environment in approximately 12 U.S. Army laboratories representing a broad range of mission requirements. The Committee has set aside November 1982 through February 1983 for these visits. The Committee will also, during this time, visit a number of non-Army government and private sector laboratories with reputations for excellence and productivity. At its September meeting, it nominated your laboratory as one that would provide it with a good understanding of the Army's work in the areas of_____.

The Committee therefore requests that you host a group of approximately ten Committee members and staff at your facility on the ___ of _____. The purposes of the Committee's visit are two. The first is to meet separately with (a) you, (b) some of your managers and supervisors, and (c) a representative sample of your staff members to discuss the professional environment of your facility, the quality of the laboratory's work, and the utilization of its professional personnel. The second is to tour those portions of the laboratory that you feel give a fair picture of the state of its physical plant, equipment, and support functions, and of the work underway.

The exact format of the Committee's visit is of course up to you. However, the Committee requests that you allow it to begin its visit by talking with you and some of your managers and supervisors, so that it may be properly oriented at the outset with respect to the laboratory's mission and its work. In these initial sessions, the Committee would like to discuss such topics as:

- The laboratory's effectiveness in the transfer of technology to users
- Administrative and other factors that impact management's ability to carry out the laboratory's mission
- The staff's understanding of the laboratory's mission and objectives
- Your perception of the laboratory's strengths and weaknesses
- Promotion, assignment, and transfer policies
- Incentives and awards for superior work
- Suggestions for improving the quality of the laboratory's work and for increasing satisfaction among its scientists, engineers and technical personnel.

In addition, the Committee would find it most helpful to receive a certain amount of data on the laboratory prior to its visit. For example, you might contribute a statement of the laboratory's mission; an organization

chart of the laboratory and its interfaces with other Army elements; total personnel numbers (broken out by discipline, age, GS rating, function, educational degree, source of recruitment, etc.); turnover rates (broken out by discipline, age, GS rating, function, educational degree, source of recruitment, length of service, etc.); current budgetary figures (e.g. funds set aside for equipment and instruments, direct labor, overhead, and the proportion of funds spent on outside contracts); work output as measured (for example) by patents, publications, awards, problems solved, and hardware developed; and accounts of any personnel surveys conducted recently.

The Committee wants to emphasize that the information gathered in these site visits will be used only in the Committee's deliberations as it studies whether Army recruitment, retention, and utilization practices affecting scientific, engineering, and technical personnel are appropriate to ensure high-quality work in Army laboratories. Specific comments and statements will not be attributed to particular individuals without their consent, and conclusions reached by the Committee will be based on data gathered from a representative sample of laboratories--not just one facility. In no instance will the material be used by the Committee to evaluate the performance of a particular Army laboratory against another. As noted previously, the Committee's objective is to identify steps that the Army could take to enhance the professional environment in its laboratories.

The Committee realizes that a number of initiatives have been undertaken by the Department of Defense and the Army over the last several years on topics related to this assessment. It nevertheless believes that its terms of reference give it a unique opportunity to contribute to the development of an evaluation system by which the quality of scientists, engineers, and technical professionals may be characterized by their output and value to the Army. The Committee hopes that you and your laboratory will be able and willing to work with it on this important task.

Sincerely,

John W. Landis
Chairman, Committee
on Army Manpower

SAMPLE OF THE COMMITTEE'S REQUEST LETTER
TO NON-ARMY LABORATORY DIRECTORS

(Date)

(Addressee)

Dear :

The U.S. Department of the Army, through the Office of the Deputy Chief of Staff for Research, Development and Acquisition, has asked the National Research Council's Board on Army Science and Technology (BAST) to conduct an assessment of the professional environment and utilization of military and civilian scientists, engineers, and technical personnel in Army laboratories. In response to this request, BAST has established a Committee on Army Manpower whose primary objective is to identify possible steps which the Army could take to enhance the professional environment of its laboratories in order to ensure high qualities of performance and effective implementation of mission requirements.

The Committee will examine at first hand the professional environment in about 12 U.S. Army laboratories, representing a broad range of mission requirements. The Committee has set aside November 1982 through February 1983 for these visits. The Committee will also, during this time, visit a number of non-Army government and private sector laboratories with reputations for excellence and productivity. Your laboratory was nominated by the Committee at its September meeting as one that would provide it with a good understanding of a high-quality work environment in the areas of _____.

The Committee would be most grateful if you would be able to host a group of approximately ten Committee members and staff at your facility on the _____ of _____. The purposes

of the Committee's visit are two. The first is to meet separately with (a) you, (b) some of your managers and supervisors, and (c) a representative sample of your staff members to discuss the professional environment of your facility, the utilization of its professional personnel, and any practices and policies you have instituted that might prove beneficial to the U.S. Army in maintaining a good work environment in its laboratories. The second is to tour those portions of the laboratory that you think illustrate a high-quality work environment.

The exact format of the Committee's visit is of course up to you. However, the Committee requests that you allow it to begin its visit by talking with you and some of your managers and supervisors, so that it may be properly oriented at the outset with respect to the laboratory's mission and its work. In preparation for its visits to Army laboratories, the Committee has asked the respective laboratory directors to discuss such topics as:

- The laboratory's effectiveness in the transfer of technology to users
- Administrative and other factors that impact management's ability to carry out the laboratory's mission
- The staff's understanding of the laboratory's mission and objectives
- His perception of his laboratory's strengths and weaknesses
- Promotion, assignment, and transfer policies
- Incentives and awards for superior work
- Suggestions for improving the quality of the laboratory's work and for increasing satisfaction among its scientists, engineers, and technical personnel.

You may want to address some or all of these topics, too.

In addition, the Committee has requested that a certain amount of data on each Army laboratory be made available prior to its visit. These data include a

statement of the laboratory's mission; an organizational chart of the laboratory and its interfaces with other Army elements; total personnel numbers (broken out by discipline, age, salary, function, educational degree, source of recruitment, etc.); turnover rates (broken out by discipline, age, salary, function, educational degree, source of recruitment, length of service, etc.); current budgetary figures (e.g., funds set aside for equipment and instruments, direct labor, overhead, and the proportion of funds spent on outside contracts); work output as measured (for example) by patents, publications, awards, problems solved, and hardware developed; and accounts of any personnel surveys (e.g., attitudinal surveys) conducted recently, with results of such work in summary form. The Committee would appreciate receiving any similar data you care to submit prior to its visit to your facility.

The Committee wants to emphasize that the information gathered in these site visits will be used only in the Committee's deliberations as it studies whether Army recruitment, retention, and utilization practices affecting scientific, engineering, and technical personnel are appropriate to ensure high-quality work in Army laboratories. Specific comments and statements will not be attributed to particular individuals without their consent, and conclusions reached by the Committee will be based on data gathered from a representative sample of Army and non-Army laboratories.

The Committee realizes that a number of initiatives have been undertaken by the Department of Defense, the Army, and the private sector over the last several years on topics related to this assessment. It nevertheless believes that its terms of reference give it a unique opportunity to contribute to the development of an evaluation system by which the quality of scientists, engineers, and technical professionals in Army laboratories may be characterized by their output and value to the Army. The Committee hopes that you and your laboratory will be able and willing to work with the Committee on this important task.

Sincerely,

John W. Landis
Chairman, Committee
on Army Manpower

APPENDIX E

LABORATORY STAFF CONSULTED BY THE COMMITTEE

BALLISTIC RESEARCH LABORATORY

Robert J. Eichelberger, Director

COMBAT SURVEILLANCE AND TARGET ACQUISITION LABORATORY

Thomas E. Daniels, Deputy Director
Seymour L. Hersh, Chief, Technical Management Division
Basil Markow, Director, Radiac Division
Gerald G. Silverman, Director, Product Assurance and Test Office

COMMUNICATIONS RESEARCH AND DEVELOPMENT COMMAND

Jerome Blackman, Deputy Director, Center for Communications Systems
H. James Cashman, Deputy Director, Center for Tactical Computer Systems
Loren Diedrichsen, Director, Center for Systems Engineering and Integration
Jerry M. Dressner, Chief, Advanced Systems Concepts Division, Center for Systems Engineering and Integration
Larry Dworkin, Chief, Multichannel Division, Center for Communications Systems
Eugene Famolari, Jr., Director, Center for Communications Systems
Theodore Klein, Chief, Signal Processing Division, Center for Communications Systems
Theodore A. Pfeiffer, Technical Director
Norman Taupeka, Chief, Engineering Development Division, Center for Tactical Computer Systems
Robert Whitman, Chief, Net Radio Division, Center for Communications Systems

ELECTRONIC WARFARE LABORATORY

Robert F. Giordana, Deputy Director
Bruce C. Miller, Chief, Electro-Magnetic Vulnerability and Electronic Counter Measures Division
Robert G. Pallazzo, Chief, Electronic Warfare Protection Division

ELECTRONICS TECHNOLOGY AND DEVICES LABORATORY

Vladimer G. Gelnovatch, Director, Microwave and Signal Processing Devices Division
Jack A. Kohn, Director, Electronic Materials Research Division
Irving Reingold, Deputy Director

ENGINEER TOPOGRAPHIC LABORATORIES

Melvin Crowell, Jr., Director, Research Institute
George Lukes, Physical Scientist, Research Institute
Robert P. Maccia, Technical Director
Bruce Opitz, Chief, Mapping Development Division
Robert S. Pazak, Mathematician, Computer Sciences Laboratory
Colonel Edward Wintz, Commander and Director

FIRE CONTROL AND SMALL CALIBER WEAPON SYSTEMS LABORATORY

Dale Adams, Deputy Director
James A. Ackley, Chief, Joint Small Arms Project Office, Fire Control Division
Modesto Barbarise, Fire Control Division
John D. Corrie, Chief, Materials and Manufacturing Technology Division
Andrew Devine, Headquarters
William Ebihara, Chief, Corrosion-Corrosion Protection Section, Materials and Manufacturing Technology Division
Walter A. Gadomski, Chief, Concepts Team, Armament Division
John F. Gehbauer, Acting Chief, Armament Division
John E. Gulow, Acting Chief, Design and Production Branch, Fire Control Division
Spencer F. Hirshman, Headquarters

Sidney S. Jacobson, Associate Technical Director
Michael D. Langan, Chief, Computer Application Branch, Fire Control Division
James D. Lester, Acting Chief, Research and Development Branch, Fire Control Division
Albert H. Mitchell, Chief, Technology Branch, Armament Division
Henry J. Opat, Chief, Technology Exploitation Team, Systems Division
Major Morris Price, Executive Officer
Lieutenant Colonel Edwin Ranels, Chief, Systems Division
Colonel Murray G. Swindler, Commander and Director
John Woods, Chief, Transition Control Group, Systems Division

INTERNATIONAL BUSINESS MACHINES CORPORATION
(OWEGO ENGINEERING LABORATORY AND GLENDALE/ENDICOTT PRODUCT LABORATORY)

Richard W. Bergeman, Manager, Development Engineering, Owego
Richard P. Case, Director, Glendale/Endicott
M. M. Dickinson, Director, Owego
Galen I. Ho, Manager, Digital Systems Programs, Owego
George G. Houser, General Manager, Federal Systems Division, Owego
William J. Patzer, Manager, Engineering and Test Support, Owego
Sam R. Pulford, Director, Electronics, Intelligence/Defense Systems, Owego
Robert O. Sogard, Manager, Software Development, Owego

LARGE CALIBER WEAPONS SYSTEMS LABORATORY

June Bright, Systems Development and Modeling Division
Jack Brooks, Acting Chief, Systems Analysis Branch, Systems Development and Modeling Division
Colonel Joseph E. Brown, Commander and Director
B. W. Bushey, Acting Chief, Munitions Systems Division
Christos Cappellos, Energetic Materials Division
Donald Casey, Energetic Systems Process Division
Clifford C. Cavanaugh, Associate for Program Management
Jack V. Connors, Weapons Division
Ronald Corn, Chief, Systems Development and Modeling Division

Thomas Davidson, Acting Chief, Applied Sciences Division
Donald Ellington, Energetic Materials Division
John T. Frasier, Deputy Director
Lawrence Frauen, Chief, Self-Propelled Artillary Branch, Weapons Division
Harvey Garver, Associate for Technology
Thaddeus Gora, Applied Science Division
John W. Gregorits, Associate for Laboratory Development
Herbert Grundler, Chief, Nuclear and Fuze Division
Stephen Honickman. Nuclear and Fuze Division
Donald Jones, Benet Weapons Laboratory
John Leccacorvi, Program Support Division
John Lepore, Associate for Engineering
Paul Marinkas, Energetic Materials Division
Joseph Marsicovette, Energetic Systems Process Division
Leonora Nichols, Munitions Systems Division
Frank Owens, Energetic Materials Divison
Renata Price, Systems Development and Modeling Division
Edwin Roof, Chief, Program Support Division
Paul Rummel, Chief, Benet Weapons Laboratory
Leon Saffian, Chief, Energetic Systems Process Division
Victor Siele, Program Support Division
Thomas Simkins, Benet Weapons Laboratory
Francis Strong, Systems Development and Modeling Division
George Taylor, Nuclear and Fuze Division
Raymond C. Walker, Chief, Energetic Materials Division
Roscoe Wrenn, Chief, Weapons Division
Craig J. Wunderly, Nuclear and Fuze Division

MEDICAL RESEARCH AND DEVELOPMENT COMMAND

Colonel Harry G. Dangerfield, Deputy Commander
Major General Garrison Rapmund, Assistant Surgeon General for Research and Development and Commander of the Medical Research and Development Command
Lieutenant Colonel David Schnakenberg, Nutrition Staff Officer, Surgeon General's Office, the Pentagon

MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMMAND

Alayne A. Adams, Chemist and Branch Chief, Electrical Power Laboratory
Charles C. Chapin, Chemist, Energy and Water Resources Laboratory
John Christians, Chief, Energy and Water Resources Laboratory

Clemens S. Gailliot, Jr., Mechanical Engineer, Mechanical and Construction Equipment Laboratory
Wendell Keyes, Director, Integrated Logistics Support Engineering
Stuart Kilpatrick, Chief, Counter Surveillance/Counter Intrusion Laboratory
Thomas W. Lovelace, Technical Director
Colonel Theodore Vander Els, Commander
Sharon Vannucci, Special Assistant for Resource Management

NATICK RESEARCH AND DEVELOPMENT LABORATORIES

Robert J. Byrne, Technical Director
Captain Keith T. Duble, Chief, Combat Arms Liaison Office, Office of the Individual Soldier
Colonel James S. Hayes, Commanding Officer
Herbert L. Meiselman, Head, Factors and Food Habits Group, Science and Advanced Technology Laboratory
Wayne F. Moore, Director, Resource Management
Richard P. Richardson, Special Assistant for Planning and Program Evaluation, Technical Director's Office
George J. Schneider, Protocol Officer
John A. Sousa, Associate Technical Director for Technology

NAVAL RESEARCH LABORATORY

Alfred H. Aitken, Head, Management Information Division
Jack D. Brown, Associate Director of Research for Technical Services
Timothy Coffey, Director of Research and Acting Associate Director of Research for General Science and Technology
Captain John A. McMorris II, Commanding Officer
Richard R. Rojas, Associate Director of Research for Systems Research and Technology
Albert I. Schindler, Associate Director of Research for Material Science and Component Technology
Bruce Wald, Associate Director of Research for Space and Communications Technology

OAK RIDGE NATIONAL LABORATORY

Peter Angelini, Metals and Ceramics Division
Bill R. Appleton, Director, Surface Modification Laboratory
Stan I. Auerbach, Director, Environmental Sciences Division
Michelle Buchanan, Analytical Chemistry Division
Karl A. Erb, Technical Assistant to the Associate Director for Physical Sciences
Duane C. Larson, Engineering Physics Division
George N. Miller, Instrumentation and Controls Division
Frank A. Modine, Solid State Physics Division
Fred R. Mynatt, Director, Instrumentation and Controls Division
Herman Postma, Director
W. D. Shults, Director, Analytical Chemistry Division
Kenneth W. Sommerfeld, Executive Director
Victor J. Tennery, Director, High Temperature Materials Laboratory
James R. Weir, Director, Metals and Ceramics Division
Susan K. Whatley, Chemical Technology Division
Alexander Zucker, Associate Director for Physical Sciences

RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

Murray P. Hamlet, Director, Cold Research Division
Roger W. Hubbard, Research Chemist, Heat Research Division
Colonel Ernest M. Irons, Jr., Commanding Officer
Colonel Brendan E. Joyce, Executive Officer, Military Ergonomics Division
Kent B. Pandolf, Director, Military Ergonomics Division
James A. Vogel, Director, Exercise Physiology Division

WALTER REED ARMY INSTITUTE OF RESEARCH

Colonel Donald Butkus, Director, Division of Medicine
Colonel Craig J. Canfield, Director, Division of Experimental Therapeutics
B. Nolan Dale, Administrative Officer
Colonel Carter L. Diggs, Director, Division of Communicable Diseases and Immunology
Lieutenant Colonel Rodney A. Edge, Director, Division of Biometrics

Colonel Arthur W. Fleming, Director, Division of Surgery
Colonel Philip K. Russell, Director
Lieutenant Colonel Frank J. Sodetz, Deputy Director
Colonel Fred C. Tyner, Director, Division of
Neuropsychiatry

APPENDIX F

QUESTIONS OF THE COMMITTEE WHEN MEETING WITH LABORATORY SCIENTISTS, ENGINEERS, AND TECHNICIANS

OPENING QUESTIONS

1. What work do you do?
2. How long have you been at the laboratory?
3. Have you done this type of work elsewhere? If so, where?

MORALE

4. Do you feel that your skills are being utilized properly, or to put it another way, do you feel that your work is challenging?
5. If you did not work here, where would you like to work? And what kind of work would you like to do?
6. What is the morale of the scientific and engineering work force here? How is this affected by factors such as pay, promotion opportunities, the physical environment and location of the laboratory, the prestige of civil service, etc.?
7. Do you feel that the work of the laboratory as a whole is significant? What about your work?

OPPORTUNITIES FOR PROMOTION, RECOGNITION, AND ADVANCED EDUCATION

8. What is your situation here as far as promotion is concerned?
   How do you feel about this situation?
9. (For military officers) Do you feel that promotion opportunities in research and development are as good as in combat arms?

10. Does the laboratory offer opportunities for you to get advanced training in your field, for example, through short courses or more formal degree programs? Are these offerings appropriate for your needs? Do you take advantage of these advanced training opportunities?
11. How does this laboratory reward employees for superior work? Is this award system appropriate?
12. Do you write papers and publish them or present them at professional meetings and conferences? Are you encouraged to do so, and does the laboratory support such efforts?

LABORATORY MANAGEMENT AND LEADERSHIP

13. What do you think about the pace of organizational change here, such as administrative rearrangements or policy changes? Is it too fast or too slow, and what affect does it have on your work?
14. How flexible are your work assignments, including both the timing (e.g., shift) and the nature (e.g., project) of your work? How difficult are transfers from one division to another within the laboratory?
15. Do you receive appropriate guidance from management in selecting and carrying out projects?
16. Does management respond to your ideas about projects and about the laboratory in general?

QUALITY OF PERSONNEL AND OF RECRUITMENT

17. What do you think about the hiring of new scientists and engineers here? Are there too many? Too few? Are they hired at the right level? Are they hired in the right speciality?
18. In general, do you feel that your supervisors and top management have appropriate technical competence?
19. Are you able to discuss your work with your colleagues here? Are you able to discuss your work with your colleagues outside this laboratory--for example, at professional meetings and conferences, with contractors, and with scientific and engineering personnel employed at other laboratories?

20. How are you affected by the turnover among your colleagues and other workers here?

SUPPORT FOR PROFESSIONAL ACTIVITIES

21. Do you get sufficient secretarial, technical, shop, and computer and other equipment support to do your job effectively and efficiently?
22. How would you rate the equipment you work with? Is it of the highest quality? Is it adequate to do your job?

CLOSING QUESTIONS

23. If you were the laboratory director or his superior, and you wanted to improve the quality of the lab's work and increase satisfaction among its employees, what changes would you recommend?
24. How does the professional environment of this lab compare to the professional environment when you first started to work here? Are you familiar with the professional environment of other laboratories which do similar work? If so, how do those environments compare with this one?
25. Are there other aspects of your professional work environment here at the lab that you think are important for us to discuss and understand?

APPENDIX G

LIST OF PRINCIPAL DOCUMENTS REVIEWED BY THE COMMITTEE

Army Armament Research and Development Command. [n.d.] Laboratory Posture Report FY82. Report No. RCS-DRCLD-101. Dover, N.J.: U.S. Army Armament Research and Development Command.

Army R, D & A Magazine. 1982. Special issue on the role of the Army labs in research, development, and acquisition. 23(4). July-Aug.

Army Science Board. 1982. Report of the Army Science Board 1982 Summer Study Panel on Science and Engineering Personnel. Washington, D.C.: Department of the Army, Assistant Secretary of the Army for Research, Development and Acquisition. (For official use only.) Sept. 28.

Atwater, D. M., et al. 1981. An Application of Integrated Human Resource Planning Supply-Demand Models. Research Report No. 39. Washington, D.C.: Office of the Assistant Secretary of the Navy for Manpower and Reserve Affairs, The Pentagon, Washington, D.C. 20310. July.

Center for Strategic and International Studies. 1982. Research and Development for Military Strength: Concerns and Recommendations (Work of the Panel on Science and Technology). Washington, D.C.: Georgetown University. Apr.

Communications-Electronics Command. [n.d.] FY 1981 Annual Posture Report. Document No. RCS DRCLD-101. Fort Monmouth, N.J.: U.S. Army Communications-Electronics Command.

Comptroller General of the United States. 1982. Internal Control Weaknesses at Department of Energy Research Laboratories. GAO/AFMD-83-38. Washington, D.C.: U.S. General Accounting Office. Dec. 15.

Cooper, Edith F. 1981. United States Supply and Demand of Scientists and Engineers: Effects on Defense Research and Technology, Part I--Current Situation and Future Outlook. Washington, D.C.: Congressional Research Service. Nov. 6.

Davidson, Harold F. 1980. Department of Defense In-House RDT&E Activities. Prepared for U.S. Army Materiel Development and Readiness Command. Alexandria, Va. Oct. 30.

Davis, Jill M. 1979. Corps Work Force Mobility. Washington, D.C.: U.S. Army Engineer Studies Center. July.

Davis, Jill M. 1980. Managing the Corps Work Force. Washington, D.C.: U.S. Army Engineer Studies Center. July.

Davis, Jill M., John J. Taylor, James R. Kirkpatrick, John O. Mosher, and Johnathan S. Thompson. 1980. Developing and Managing the Corps Work Force for Future Missions. Washington, D.C.: U.S. Army Engineer Studies Center. July.

Defense Science Board. 1981. Report of the Defense Science Board 1981 Summer Study Panel on Technology Base. Copies available from the Office of the Under Secretary of Defense for Research and Engineering, The Pentagon, Washington, D.C. 20310. Nov.

Defense Science Board. 1982. Report of the Defense Science Board Task Force on University Responsiveness to National Security Requirements. Copies available from the Office of the Under Secretary of Defense for Research and Engineering, The Pentagon, Washington, D.C. 20310. Jan.

DeLauer, Richard D. 1982. The FY 1983 Department of Defense Program for Research, Development, and Acquisition. Statement to the 97th Congress, Second Session. Washington, D.C.: U.S. Department of Defense. Mar. 2.

Doolittle, Fred C., George Nasmith, Philip L. Clay, and Gregory A. Jackson. 1982. Future Boston: Patterns and Perspectives. Cambridge, Mass.: Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University.

Energy Research Advisory Board. 1982. Final Report of the Multiprogram Laboratory Panel of the Energy Research Advisory Board. Washington, D.C.: U.S. Department of Energy. Sept.

Engineer Topographic Laboratories. 1982. Laboratory of the Year Report. Copies available through the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Va.

Hermann, Robert J. 1982. USDRE Independent Review of DoD Laboratories. Prepared for the Under Secretary for Defense Research and Engineering, U.S. Department of the Army. Washington, D.C. Mar.

Jackson, Gregory A., and Robert W. Mueller, Jr. 1981a. On Projections of Jobs for Scientists and Engineers. Prepared for the Commission on Human Resources, National Research Council. Boston, Mass.: Harvard University. Dec.

Jackson, Gregory A., George Nasmith, Roger Bolton, Susan Bartlett, and John Pitkin. 1981b. Regional Diversity on Growth in the U.S., 1960-1990. Boston, Mass.: Auburn House.

Large Caliber Weapons Systems Laboratory. 1982. In-House Laboratory Independent Research (ILIR) Program: Final Report for FY 82. Report No. RCS CSCRD-105. Dover, N.J.: U.S. Army Armament Research and Development Command. Sept.

Mitchell, James N. 1982. A Framework Linking Findings of the Army Science Board Summer Studies to the Need for Improved Scientific, Engineering, and Technical Manpower in the Army. Prepared for the 1982 Army Science Board Summer Study on Scientists and Engineers. Copies available from the Office of the Director of Army Research, The Pentagon, Washington, D.C. May.

Mobility Equipment Research and Development Command. 1982. Army Laboratory Engineering Manpower Questions. Material provided to the Army Science Board 1982 Summer Study on Science and Engineering Personnel. Fort Belvoir, Va.: U.S. Army Mobility Equipment Research and Development Command.

Moser, John O. 1979. Management Implications of the Civil Service Reform Act (CSRA). Washington, D.C.: U.S. Army Engineer Studies Center. Sept.

Moser, John O. 1980. Work Force Training and Development for the 1980's. Washington, D.C.: U.S. Army Engineer Studies Center. July.

National Research Council. 1977. Modeling and Simulation for Engineering Manpower Studies: Proceedings of a Conference. Board on Engineering Manpower and Education Policy. Copies available from Commission on Engineering and Technical Systems, National Research Council, Washington, D.C.

National Research Council. 1981. The Education and Utilization of Engineers: Recommendations for a Study. Committee on the Education and Utilization of the Engineer. Washington, D.C.: National Academy Press.

National Research Council. 1981. The Effect of Military Personnel Requirements on the Future Supply of Scientists and Engineers in the United States: Papers and a Conference Report. Commission on Human Resources. Washington, D.C.: National Academy Press.

Naval Research Laboratory. 1981. 1981 Review. Washington, D.C.

Naval Research Laboratory. 1982. NRL Fact Book '82. Washington, D.C.

Oak Ridge National Laboratory, Program Planning and Analysis Office. 1982. Oak Ridge National Laboratory Institutional Plan FY 1983-FY 1988. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Thompson, Jonathan S. 1980. The Corps Work Force in Transition. Washington, D.C.: U.S. Army Engineer Studies Center. July.

U.S. Army Materiel Command. 1964. Study on Technical Missions, Structure, and Career Development. Report No. UB413A21. Copies available from the Army Library, The Pentagon, Washington, D.C. 20310. June.

U.S. Army Natick Research and Development Laboratories. [n.d.] Annual Historical Review: 1 October 1980-30 September 1981. Document No. RCS CSHIS-6 (R3), Natick, Mass.

U.S. Army Natick Research and Development Laboratories. 1981. Organization and Functions. Document No. NLABS REG No. 10-2. Natick, Mass. Jan. 1.

U.S. Army Natick Research and Development Laboratories. [n.d.] Posture Report FY 81. Natick, Mass.

U.S. Department of Defense. 1981. DoD Research and Development Laboratories. Department of Defense Instruction No. 3201.3. Copies available from the Under Secretary of Defense for Research and Engineering (Research and Advanced Technology), The Pentagon, Washington, D.C. 20310. Mar. 31.

U.S. Department of Defense Laboratory Management Task Force, Personnel and Manpower Working Group. 1982. Study of Scientists and Engineers in DOD Laboratories. Copies available from the Office of the Deputy Assistant Secretary of the Navy for Research, Engineering and Systems, The Pentagon, Washington, D.C. 20310. June.

Vetter, Betty M. 1982. Supply and Demand for Scientists and Engineers. Washington, D.C.: Scientific Manpower Commission. Jan.

Walter Reed Army Institute of Research. [n.d.] Walter Reed Army Institute of Research: 1982. Washington, D.C.: U.S. Department of the Army.

Zinsmeister, Paul. 1981. Engineering Manpower: A Survey of the National Problem and the Problem in the Department of Defense. Washington, D.C.: Congressional Research Service. Dec. 21.

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